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sahilbansal17 Add CPP solution ... on 22 Aug 2019 6

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README.md

3Sum

Problem Statement

Given an array of **nums** of **n** integers, are there elements a, b, c in **nums** such that $a + b + c = 0$? Find all unique triplets in the array which gives the sum of zero.

About

Solution article for the leetcode problem 3Sum

Readme

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C++ 100.0%

Note

The solution set must not contain duplicate triplets.

Example

Given array `nums = [-1, 0, 1, 2, -1, -4]`,

A solution set is:

`[ [-1, 0, 1], [-1, -1, 2] ]`

Solution Approach 1 - Brute Force (Time Limit Exceeded)

Consider all possible triplets using 3 nested loops, and if the sum of the triplet equals 0, add it to a set of vector (after sorting those 3 numbers). This will make sure that the final result doesn't contain any duplicate triplets.

Time Complexity

This solution takes a time complexity of `O(N^3 log N)` since insertion in the set will take `O(log N)` time.

Solution Approach 2 - Two Pointers

Intuition

Let's say we fixed one of the numbers in the triplets as `x` and other numbers be `y` and `z`. Thus, `y + z = -x`.

If we had sorted the elements in the given array, we can easily find a pair with given sum value using a `two-pointer` approach.

We maintain one `start` pointer at the beginning of the array, and an `end` pointer at the end of the array.

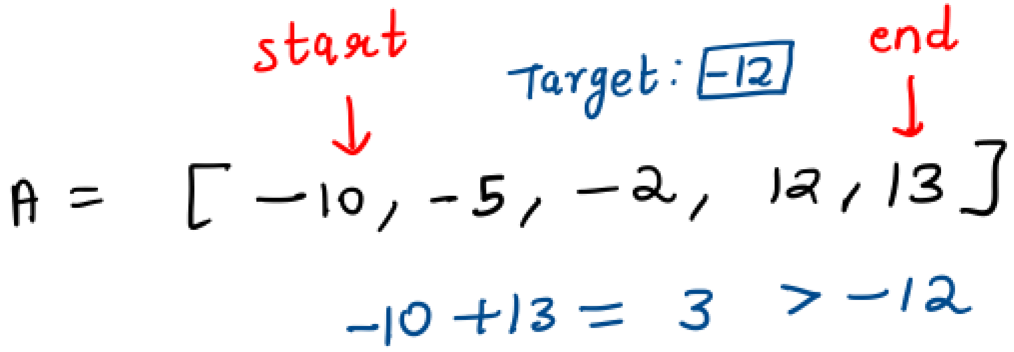
Considering the sum of values at these 2 positions:

- Less than the `target` : Shift the `start` pointer to right.
- Greater than the `target` : Shift the `end` pointer to the left.
- Equals the `target` : Congrats! You've found the pair.

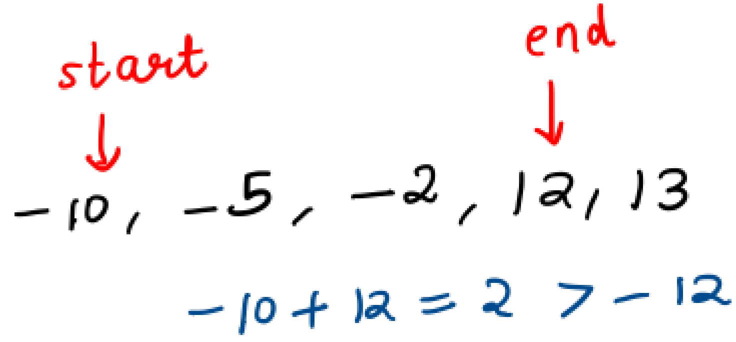
Let us understand the 2-pointer approach to find pair with given sum. Consider the given array (sorted) as

```
A = [-10, -5, -2, 12, 13]
```

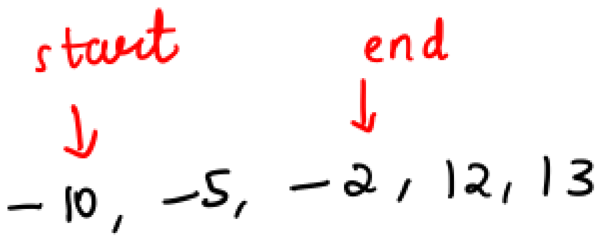
and you need to find a pair with sum = -12.



Initially, sum = 3 which is more than -12, thus shifting the end pointer to left.



Again, shifting the end pointer to the left.



Finally, you get a pair with sum = target.

We still need to make sure that we do not get duplicate triplets, and we do not miss one!

Algorithm

Let's take an example to develop the algorithm.

```
A = [-2, -2, -1, -1, 0, 1, 1, 2, 2]
```

Let's say we were to consider first -2 as fixed. Now, we need to find pairs with sum = 2 in the remaining array.
i.e. pairs with **target = 2** in `A' = [-2, -1, -1, 0, 1, 1, 2, 2]`

To find multiple pairs, we can do the following modification:
Whenever pair sum = target, shift both start and end pointers to right and left respectively.
So, we will get `(0, 2)` and `(1, 1)` as the required pairs and hence `(-2, 0, 2)` and `(-2, 1, 1)` as the corresponding triplets.

Now, considering the next `-2` in the array, can we simply ignore the left part of the array?
Exactly, because we already found all possible pairs taking elements in the left part as fixed.
So, for the second `-2` in the array, the array to look is just to the right of it, i.e. `A' = [-1, -1, 0, 1, 1, 2, 2]`.

But, now how do we ensure that no duplicate triplets are present in the result?
If we use an additional set to store the results, it will be require additional space, as well as insertion would take `O(log N)`. Can we do it more **efficiently**?

Let's consider another example:
`B = [-2, -2, -2, 1, 1, 4, 4]`

- So, let's start with the `-2` at index `0`.
    - Let's find all pairs with sum `2`.
    - They come out to be `(-2, 4), (-2, 4), (1, 1)`.
    - At each step, we shift both the `start` and `end` pointers since sum exactly matches target.

      Could we have avoided the duplicate `(-2, 4)` getting in our way? YES.
      See that we can simply move the `start` pointer while it matches its old value (-2) and similarly shift the `end` pointer till it matches its old value (4).
- Now, let's come to the `-2` at index `1`.
    - As per our approach, we will see to its right to get pairs with sum `2`.

  - But, we have already considered all possible pairs with `sum = 2` for the previous `-2`.
  - So, we can simply ignore this element for further processing to avoid duplicates.

From this example, we have found out a way to avoid duplicates.

- We can simply move our first element of triplet to the right till it matches the previous number.
- While finding the pair with sum equal to negation of fixed element, we can shift the start/end pointers till they refer to the same values (old start/end).

Time Complexity

- First of all, array is sorted incurring `O(n log n)`.
- We are then fixing the first element of the triplet in the outer loop running over all the elements.
- In the inner loop, we find a pair with sum equals negation of number fixed in outer loop, using two-pointer approach and avoiding duplicates smartly.

Thus, overall time complexity = `O(nlogn + n*n) = O(n^2)`

Implementation

C++ Code

```
class Solution {
public:
    vector<vector<int>> threeSum(vector<int>& nums) {
      vector<vector<int>> res;

      // size of the array nums
```

```
      int total = nums.size();

      // sort the numbers
      sort(nums.begin(), nums.end());

      // fix the first number of the triplet
      for (int firstNumIdx = 0; firstNumIdx < total; ++firstNumIdx) {
        int firstNum = nums[firstNumIdx];
        // find pairs with sum = -firstNum in the right
        int start = firstNumIdx + 1;
        int end = total - 1;
        while (start < end) {
          // consider the current pair sum
          int current = nums[start] + nums[end];
          if (current < -firstNum) {
            // shift the start pointer to the right
            ++start;
          } else if (current > -firstNum) {
            // shift the end pointer to the left
            --end;
          } else {
            // add to the result
            res.push_back({firstNum, nums[start], nums[end]});
            int oldStart = start;
            int oldEnd = end;
            // shift the start till it matches the old value
            while (start < end && nums[start] == nums[oldStart]) {
              ++start;
            }
            // shift the end till it matches the old value
            while (end > start && nums[end] == nums[oldEnd]) {
              --end;
            }
            // the above two while loops ensure that both start/end
            // get shifted atleast once
          }
```

```
            // avoid duplicates
            while (firstNumIdx + 1 < total
                   && nums[firstNumIdx + 1] == nums[firstNumIdx]) {
              ++firstNumIdx;
            }
          }
        }

        return res;
      }
};
```