<https://leetcode.com/problems/subsets-ii/>

Given an integer array nums that may contain duplicates, return *all possible subsets (the power set)*.

The solution set **must not** contain duplicate subsets. Return the solution in **any order**.

**Example 1:**

Input: nums = [1,2,2]

Output: [[],[1],[1,2],[1,2,2],[2],[2,2]]

**Example 2:**

Input: nums = [0]

Output: [[],[0]]

**Constraints:**

* 1 <= nums.length <= 10
* -10 <= nums[i] <= 10

**Attempt 1: 2022-10-8**

**Solution 1: Backtracking style 1 (10min)**

class Solution {

public List<List<Integer>> subsetsWithDup(int[] nums) {

List<List<Integer>> result = new ArrayList<List<Integer>>();

Arrays.sort(nums);

helper(nums, result, new ArrayList<Integer>(), 0);

return result;

}

private void helper(int[] nums, List<List<Integer>> result, List<Integer> tmp, int index) {

result.add(new ArrayList<Integer>(tmp));

for(int i = index; i < nums.length; i++) {

if(i > index && nums[i] == nums[i - 1]) {

continue;

}

tmp.add(nums[i]);

helper(nums, result, tmp, i + 1);

tmp.remove(tmp.size() - 1);

}

}

}

Time complexity: O(N×2^N) to generate all subsets and then copy them into output list.

Space complexity: O(N). We are using O(N) space to maintain curr, and are modifying curr in-place with backtracking. Note that for space complexity analysis, we do not count space that is only used for the purpose of returning output, so the output array is ignored.

**Solution 2: Backtracking style 2 (720min, too long to sort out why local variable to skip duplicate elements is mandatory)**

**Correct solution 2.1 with local variable 'i' to skip duplicate elements on particular "Not pick" branch**

class Solution {

public List<List<Integer>> subsetsWithDup(int[] nums) {

List<List<Integer>> result = new ArrayList<List<Integer>>();

Arrays.sort(nums);

helper(nums, result, new ArrayList<Integer>(), 0);

return result;

}

private void helper(int[] nums, List<List<Integer>> result, List<Integer> tmp, int index) {

if(index >= nums.length) {

result.add(new ArrayList<Integer>(tmp));

return;

}

int i = index;

while(i + 1 < nums.length && nums[i] == nums[i + 1]) {

i++;

}

// Not pick

helper(nums, result, tmp, i + 1);

// Pick

tmp.add(nums[index]);

helper(nums, result, tmp, index + 1);

tmp.remove(tmp.size() - 1);

}

}

Space complexity: O(n + n \* 2^n) = O(n \* 2^n)

For recursion: max depth the call stack is going to reach at any time is length of nums, n.

For output: we're creating 2^n subsets where the average set size is n/2 (for each A[i], half of the subsets will include A[i], half won't) = n/2 \* 2^n = O(n \* 2^n). Or in a different way, the total output size is going to be the summation of the binomial coefficients, the total number of r-combinations we can make at each r size \* r elements from 0..n which evaluates to n\*2^n. More informally, at size 0, how many empty sets can we make from n elements, then at size 1 how many subsets of 1 elements can we make from n elements, at size 2, how many subsets of 2 elements can we make ... at size n, etc.

So total is call stack of n + output of n \* 2^n = O(n \* 2^n). If we don't include the output (eg if just asked to print in an interview) then just O(n) of course.

Time Complexity: O(n \* 2^n)

The recursive function is called 2^n times. Because we have 2 choices at each iteration in nums array. Either we include nums[i] in the current set, or we exclude nums[i]. This array nums is of size n = number of elements in nums.

We need to create a copy of the current set because we reuse the original one to build all the valid subsets. This copy costs O(n) and it is performed at each call of the recursive function, which is called 2^n times as mentioned in above. So total time complexity is O(n x 2^n).

**Progress of correct solution 2.1**

Round 1:

nums={1,2,2,3},result={},tmp={},index=0

helper({1,2,2,3},{},{},0)

i=0 -> no skip happening

--------------------------------------------

Round 2:

nums={1,2,2,3},result={},tmp={},index=0

helper({1,2,2,3},{},{},0+1)

i=index=1 -> nums[1]=2 == nums[1+1]=2 -> i++=2 skip happening

--------------------------------------------

Round 3:

nums={1,2,2,3},result={},tmp={},index=2

helper({1,2,2,3},{},{},2+1)

i=index=3 -> no skip happening

--------------------------------------------

Round 4:

nums={1,2,2,3},result={},tmp={},index=3

helper({1,2,2,3},{},{},3+1)

index=4 == nums.length -> result={{}}

return to Round 3 statistics

--------------------------------------------

Round 5: Continue from Round 3

index=3

tmp.add(nums[3])=tmp.add(3)={3}

--------------------------------------------

Round 6:

nums={1,2,2,3},result={{}},tmp={3},index=3

helper({1,2,2,3},{{}},{3},3+1)

index=4 == nums.length -> result={{}{3}}

return to Round 5 statistics

tmp.remove(1-1)={}

End statement back to Round 2 statistics

--------------------------------------------

Round 7:

index=1

tmp.add(nums[1])=tmp.add(2)={2}

--------------------------------------------

Round 8:

nums={1,2,2,3},result={{}{3}},tmp={2},index=1

helper({1,2,2,3},{{}{3}},{2},1+1)

i=index=2

helper({1,2,2,3},{{}{3}},{2},2+1)

i=index=3

helper({1,2,2,3},{{}{3}},{2},3+1)

index=4 == nums.length -> result={{}{3}{2}}

return to index=3 statistics

--------------------------------------------

Round 9:

tmp.add(nums[3])={2,3}

helper({1,2,2,3},{{}{3}{2}},{2,3},3+1)

index=4 == nums.length -> result={{}{3}{2}{2,3}}

return to index=3 statistics

tmp.remove(2-1)={2}

end statement back to Round 8 statistics

--------------------------------------------

Round 10:

tmp={2},index=2

tmp.add(nums[2])={2,2}

helper({1,2,2,3},{{}{3}{2}{2,3}},{2,2},2+1)

i=index=3

--------------------------------------------

Round 11:

helper({1,2,2,3},{{}{3}{2}{2,3}},{2,2},3+1)

index=4 == nums.length -> result={{}{3}{2}{2,3}{2,2}}

return to index=3 statistics

--------------------------------------------

Round 12:

tmp.add(nums[3])={2,2,3}

helper({1,2,2,3},{{}{3}{2}{2,3}{2,2}},{2,2,3},3+1)

index=4 == nums.length -> result={{}{3}{2}{2,3}{2,2}{2,2,3}}

return to index=3 statistics

tmp.remove(3-1)={2,2}

tmp.remove(2-1)={2}

tmp.remove(1-1)={}

--------------------------------------------

Round 13:

tmp={},index=0

tmp.add(nums[0])={1}

helper({1,2,2,3},{{}{3}{2}{2,3}{2,2}{2,2,3}},{1},0+1)

i=index=1 -> nums[1]=2 == nums[1+1]=2 -> i++=2 skip happening

--------------------------------------------

Round 14:

helper({1,2,2,3},{{}{3}{2}{2,3}{2,2}{2,2,3}},{1},2+1)

i=index=3 -> no skip happening

--------------------------------------------

Round 15:

helper({1,2,2,3},{{}{3}{2}{2,3}{2,2}{2,2,3}},{1},3+1)

index=4 == nums.length -> result={{}{3}{2}{2,3}{2,2}{2,2,3}{1}}

return to index=3 statistics

--------------------------------------------

Round 16:

tmp.add(nums[index])=tmp.add(nums[3])={1,3}

index=4 == nums.length -> result={{}{3}{2}{2,3}{2,2}{2,2,3}{1}{1,3}}

return to index=3 statistics

tmp.remove(2-1)={1}

return to index=1 statistics

--------------------------------------------

Round 17:

tmp.add(nums[index])=tmp.add(nums[1])={1,2}

helper({1,2,2,3},{{}{3}{2}{2,3}{2,2}{2,2,3}{1}{1,3}},{1,2},1+1)

i=index=2

helper({1,2,2,3},{{}{3}{2}{2,3}{2,2}{2,2,3}{1}{1,3}},{1,2},2+1)

i=index=3

helper({1,2,2,3},{{}{3}{2}{2,3}{2,2}{2,2,3}{1}{1,3}},{1,2},3+1)

i=index=4 == nums.length -> result={{}{3}{2}{2,3}{2,2}{2,2,3}{1}{1,3}{1,2}}

return to index=3 statistics

--------------------------------------------

Round 18:

tmp.add(nums[3])={1,2,3}

helper({1,2,2,3},{{}{3}{2}{2,3}{2,2}{2,2,3}{1}{1,3}{1,2}},{1,2,3},3+1)

index=4 == nums.length -> result={{}{3}{2}{2,3}{2,2}{2,2,3}{1}{1,3}{1,2}{1,2,3}}

return to index=3 statistics

tmp.remove(3-1)={1,2}

end statement back to index=2 statistics

--------------------------------------------

Round 19:

tmp.add(nums[2])={1,2,2}

helper({1,2,2,3},{{}{3}{2}{2,3}{2,2}{2,2,3}{1}{1,3}{1,2}},{1,2,2},2+1)

i=index=3

helper({1,2,2,3},{{}{3}{2}{2,3}{2,2}{2,2,3}{1}{1,3}{1,2}},{1,2,2},3+1)

index=4 == nums.length -> result={{}{3}{2}{2,3}{2,2}{2,2,3}{1}{1,3}{1,2}{1,2,3}{1,2,2}}

return to index=3 statistics

--------------------------------------------

Round 20:

tmp.add(nums[3])={1,2,2,3}

helper({1,2,2,3},{{}{3}{2}{2,3}{2,2}{2,2,3}{1}{1,3}{1,2}{1,2,2}},{1,2,2,3},3+1)

index=4 == nums.length -> result={{}{3}{2}{2,3}{2,2}{2,2,3}{1}{1,3}{1,2}{1,2,3}{1,2,2}{1,2,2,3}}

return to index=3 statistics

tmp.remove(4-1)={1,2,2}

tmp.remove(3-1)={1,2}

tmp.remove(2-1)={1}

tmp.remove(1-1)={}

--------------------------------------------

End

============================================

Result time elapsed statistics:

result={{}}

result={{}{3}}

result={{}{3}{2}}

result={{}{3}{2}{2,3}}

result={{}{3}{2}{2,3}{2,2}}

result={{}{3}{2}{2,3}{2,2}{2,2,3}}

result={{}{3}{2}{2,3}{2,2}{2,2,3}{1}}

result={{}{3}{2}{2,3}{2,2}{2,2,3}{1}{1,3}}

result={{}{3}{2}{2,3}{2,2}{2,2,3}{1}{1,3}{1,2}}

result={{}{3}{2}{2,3}{2,2}{2,2,3}{1}{1,3}{1,2}{1,2,3}}

result={{}{3}{2}{2,3}{2,2}{2,2,3}{1}{1,3}{1,2}{1,2,3}{1,2,2}}

result={{}{3}{2}{2,3}{2,2}{2,2,3}{1}{1,3}{1,2}{1,2,3}{1,2,2}{1,2,2,3}}

**Correct solution 2.1 recursion step by step picture**

Start from index=1 (level 2) "Not pick first 2 branch" also will not pick second 2, local variable 'i' helps skip happen only on "Not pick first 2 branch" and not impact "Pick first 2 branch"

{ }

/ \

{ } {1} -> [(1),2,2,3]:index=0(level1)

/ \ / \

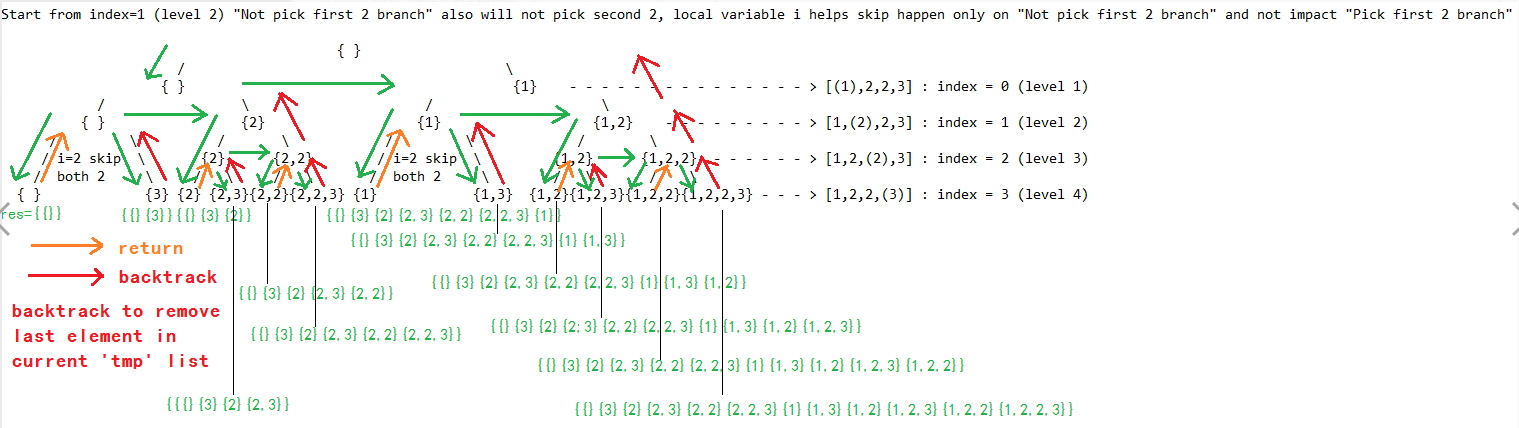
{ } {2} {1} {1,2} -> [1,(2),2,3]:index=1(level2)

/ \ / \ / \ / \

/ i=2 skip \ {2} {2,2} / i=2 skip \ {1,2} {1,2,2} -> [.2(2).]:index=2(level3)

/ both 2 \ / \ / \ / both 2 \ / \ / \

{ } {3} {2} {2,3}{2,2}{2,2,3} {1} {1,3} {1,2}{1,2,3}{1,2,2}{1,2,2,3}[..(3)]:idx=3(level4)



**If not skip both 2 in "Not pick first 2 branch", what will happen ?**

{ }

/ \

{ } {1} -> [(1),2,2,3]:index=0(level1)

/ \ / \

{ } {2} {1} {1,2} -> [1,(2),2,3]:index=1(level2)

/ \ / \ / \ / \

{ } No skip {2} {2} {2,2} {1} No skip {1,2} {1,2} {1,2,2} -> [.2(2).]:index=2(level3)

/ / \ / \ / \ / / \ / \ / \

{ } {2} {2,3} {2} {2,3}{2,2}{2,2,3} {1} {1,2}{1,2,3}{1,2}{1,2,3}{1,2,2}{1,2,2,3}[..(3)]:idx=3(level4)

Duplicate Duplicate

**We can see duplicate subsets generated as {2}{2,3}{1,2}{1,2,3} based on second 2 (index=2), which not happen in correct solution because we skip second 2 in "Not pick first 2" branch**

**Correct solution 2.2 with local variable 'i' to skip duplicate elements on particular "Not pick" branch**

class Solution {

public List<List<Integer>> subsetsWithDup(int[] nums) {

List<List<Integer>> result = new ArrayList<List<Integer>>();

Arrays.sort(nums);

helper(nums, result, new ArrayList<Integer>(), 0);

return result;

}

private void helper(int[] nums, List<List<Integer>> result, List<Integer> tmp, int index) {

if(index >= nums.length) {

result.add(new ArrayList<Integer>(tmp));

return;

}

// Not pick

// Not add, then we will not add all the following same element, just jump to the index where nums[index] is a different value

int i = index;

while(i < nums.length && nums[i] == nums[index]) {

i++;

}

// Be careful, the next "Not pick" recursion start from 'i' not 'i + 1',

// because nums[i] is the first element different than nums[index] not

// nums[i + 1]

// Compare to below style

// while(i + 1 < nums.length && nums[i] == nums[i + 1]) {i++;}

// helper(nums, result, tmp, i + 1)

helper(nums, result, tmp, i);

// Pick

tmp.add(nums[index]);

helper(nums, result, tmp, index + 1);

tmp.remove(tmp.size() - 1);

}

}

**Different styles to skip duplicate elements in correct solution 2.1 and 2.2?**

e.g

For sorted array nums={1,2,2,2,5}, index=1, all duplicate '2' stored continuously in array

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For

int i = index;

while(i < nums.length && nums[i] == nums[index]) {i++;}

helper(nums, result, tmp, i);

=> while loop ending when i=4, nums[4]=5 != nums[1]=2, not pick up branch skip all duplicate 2 and start from 5 requires pass i(=4) to next recursion

-------------------------------------

For

int i = index;

while(i + 1 < nums.length && nums[i] == nums[i + 1]) {i++;}

helper(nums, result, tmp, i + 1);

=> while loop ending when i=3, nums[3]=2 != nums[4]=5, not pick up branch skip all duplicate 2 and start from 5 requires pass i + 1(=4) to next recursion

**Wrong solution without local variable 'i' to skip duplicate elements**

class Solution {

public List<List<Integer>> subsetsWithDup(int[] nums) {

List<List<Integer>> result = new ArrayList<List<Integer>>();

Arrays.sort(nums);

helper(nums, result, new ArrayList<Integer>(), 0);

return result;

}

private void helper(int[] nums, List<List<Integer>> result, List<Integer> tmp, int index) {

if(index >= nums.length) {

result.add(new ArrayList<Integer>(tmp));

return;

}

while(index + 1 < nums.length && nums[index] == nums[index + 1]) {

index++;

}

// Not pick

helper(nums, result, tmp, index + 1);

// Pick

tmp.add(nums[index]);

helper(nums, result, tmp, index + 1);

tmp.remove(tmp.size() - 1);

}

}

**Progress of wrong solution**

Round 1:

nums={1,2,2,3},result={},tmp={},index=0

helper({1,2,2,3},{},{},0)

--------------------------------------------

Round 2:

helper({1,2,2,3},{},{},0+1)

index=1 -> nums[index]==nums[index+1] -> i++=2 skip happening

--------------------------------------------

Round 3:

helper({1,2,2,3},{},{},2+1)

index=3

--------------------------------------------

Round 4:

helper({1,2,2,3},{},{},3+1)

index=4 == nums.length -> result={{}}

return to index=3 statistics

--------------------------------------------

Round 5:

index=3

tmp.add(nums[3])={3}

helper({1,2,2,3},{{}},{3},3+1)

index=4 == nums.length -> result={{}{3}}

tmp.remove(1-1)={}

--------------------------------------------

1st difference happening, compare to correct solution Round 7 & 8, after end statement, back to previous recursion, the index can rollback to 1, but here the index only able to rollback to 2, why?

Because in correct solution we reserve index=1 status by assigning index=1 to a new local variable 'i' and only loop on 'i' in previous recursion to skip the duplicate elements, so even 'i' change

to other value and used by "Not pick" branch "helper(nums, result, tmp, i + 1)", index=1 kept as is and used by "Pick" branch "helper(nums, result, tmp, index + 1)", the local variable 'i'

prevents the side effect of updating 'index' in all traversal branches and limits the updating only impact the "Not pick" branch. It helps us when return from further recursion back to "Pick"

branch we can still start with index=1 status, not like wrong solution here, since we globally only use 'index' and no local variable 'i' helps to isolate updating 'index' impact, it will wrongly

impact "Pick" branch

Round 6:

index=2

tmp.add(nums[2])={2}

helper({1,2,2,3},{{}{3}},{2},2+1)

index=3

helper({1,2,2,3},{{}{3}},{2},3+1)

index=4 == nums.length -> result={{}{3}{2}}

return to index=3 statistics

--------------------------------------------

Round 7:

index=3

tmp.add(nums[3])={2,3}

helper({1,2,2,3},{{}{3}},{2,3},3+1)

index=4 == nums.length -> result={{}{3}{2}{2,3}}

return to index=3 statistics

tmp.remove(2-1)={2}

tmp.remove(1-1)={}

end statement back to index=0

--------------------------------------------

Round 8:

index=0

tmp.add(nums[0])={1}

helper({1,2,2,3},{{}{3}{2}{2,3}},{1},0+1)

index=1 -> nums[index]==nums[index+1] -> i++=2 skip happening

helper({1,2,2,3},{{}{3}{2}{2,3}},{1},2+1)

index=3

helper({1,2,2,3},{{}{3}{2}{2,3}},{1},3+1)

index=4 == nums.length -> result={{}{3}{2}{2,3}{1}}

return to index=3 statistics

--------------------------------------------

Round 9:

index=3

tmp.add(nums[3])={1,3}

helper({1,2,2,3},{{}{3}{2}{2,3}{1}},{1,3},3+1)

index=4 == nums.length -> result={{}{3}{2}{2,3}{1}{1,3}}

return to index=3 statistics

tmp.remove(2-1)={1}

end statement back to index=2

--------------------------------------------

Round 10:

index=2

tmp.add(nums[2])={1,2}

helper({1,2,2,3},{{}{3}{2}{2,3}{1}{1,3}},{1,2},2+1)

index=3

helper({1,2,2,3},{{}{3}{2}{2,3}{1}{1,3}},{1,2},3+1)

index=4 == nums.length -> result={{}{3}{2}{2,3}{1}{1,3}{1,2}}

return to index=3 statistics

--------------------------------------------

Round 11:

tmp.add(nums[3])={1,2,3}

helper({1,2,2,3},{{}{3}{2}{2,3}{1}{1,3}{1,2}},{1,2,3},3+1)

index=4 == nums.length -> result={{}{3}{2}{2,3}{1}{1,3}{1,2}{1,2,3}}

return to index=3 statistics

tmp.remove(3-1)={1,2}

tmp.remove(2-1)={1}

tmp.remove(1-1)={}

--------------------------------------------

End

============================================

Result time elapsed statistics:

result={{}}

result={{}{3}}

result={{}{3}{2}}

result={{}{3}{2}{2,3}}

result={{}{3}{2}{2,3}{1}}

result={{}{3}{2}{2,3}{1}{1,3}}

result={{}{3}{2}{2,3}{1}{1,3}{1,2}}

result={{}{3}{2}{2,3}{1}{1,3}{1,2}{1,2,3}}

**Wrong solution recursion step by step picture**

Because of no local variable 'i' to inherit 'index' value and used in skip duplicate elements, in Round 6 and 7 we can see after adding 'tmp' list {2,3} into result, in wrong solution it directly start to backtrack 'tmp' list from {2,3} back to empty list {} and index=0(the correct answer only backtrack to {2}, index=2)

{ }

/ \

{ } {1} -> [(1),2,2,3]:index=0(level 1)

/ \ / \

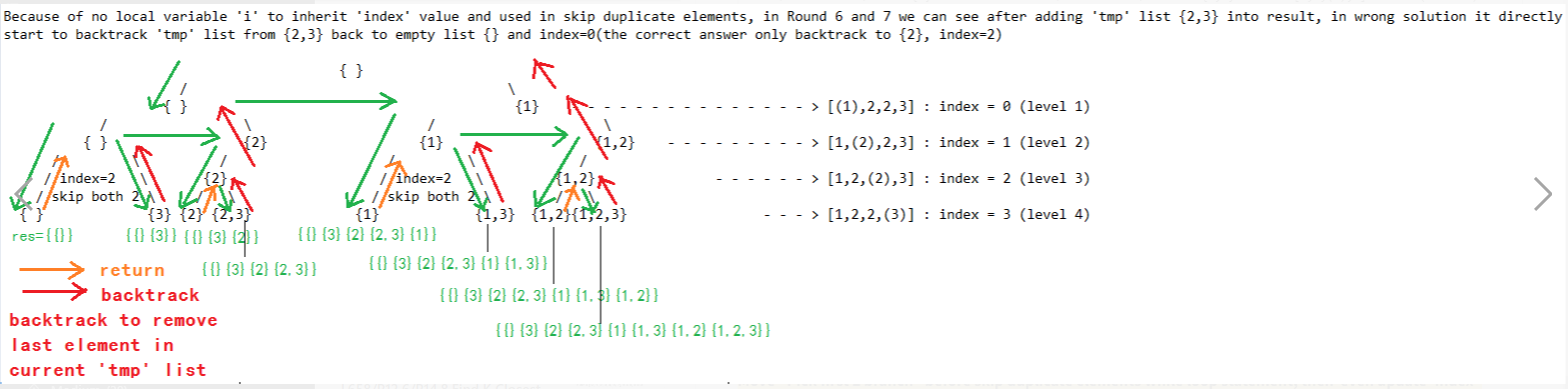
{ } {2} {1} {1,2} -> [1,(2),2,3]:index=1(level 2)

/ \ / / \ /

/ index=2 \ {2} / index=2 \ {1,2} -> [1,2,(2),3]:index=2(level 3)

/ skip both 2 \ / \ / skip both 2 \ / \

{ } {3} {2} {2,3} {1} {1,3} {1,2}{1,2,3} -> [1,2,2,(3)]:index=3(level 4)



**Alternative correct solution without local variable but switch order of "Pick" or "Not pick" branch**

**Move "Pick first 2 branch" before skip duplicate elements while loop statement, then  even update 'index' directly without local variable 'i' will only impact "Not pick first 2" branch**

class Solution {

public List<List<Integer>> subsetsWithDup(int[] nums) {

List<List<Integer>> result = new ArrayList<List<Integer>>();

Arrays.sort(nums);

helper(nums, result, new ArrayList<Integer>(), 0);

return result;

}

private void helper(int[] nums, List<List<Integer>> result, List<Integer> tmp, int index) {

if(index >= nums.length) {

result.add(new ArrayList<Integer>(tmp));

return;

}

// Move "Pick first 2 branch" before skip duplicate elements while loop statement,

// then even update 'index' directly without local variable 'i' will only impact

// "Not pick first 2" branch

// Pick

tmp.add(nums[index]);

helper(nums, result, tmp, index + 1);

tmp.remove(tmp.size() - 1);

while(index + 1 < nums.length && nums[index] == nums[index + 1]) {

index++;

}

// Not pick

helper(nums, result, tmp, index + 1);

}

}

**Why local variable to skip duplicate elements only on particular "Not pick" branch is mandatory ?**

In wrong solution process Round 6, the 1st difference happening, compare to correct solution Round 7 & 8, after end statement, back to previous recursion, the index can rollback to 1, but here in the wrong solution the index only able to rollback to 2, why? Because in correct solution we reserve index=1 status by assigning index=1 to a new local variable 'i' and only loop on 'i' in previous recursion to skip the duplicate elements, so even 'i' change to other value and used by "Not pick" branch "helper(nums, result, tmp, i + 1)", index=1 kept as is and used by "Pick" branch "helper(nums, result, tmp, index + 1)", the local variable 'i' prevents the side effect of updating 'index' in all traversal branches and limits the updating only impact the "Not pick" branch. It helps us when return from further recursion back to "Pick" branch we can still start with index=1 status, not like wrong solution here, since we globally only use 'index' and no local variable 'i' helps to isolate updating 'index' impact, it will wrongly impact "Pick" branch, the wrong solution above is the negative impact.

**Video explain why and how to skip duplicate elements only on particular "Not pick" branch**

[Subsets II - Backtracking - Leetcode 90 - Python](https://www.youtube.com/watch?v=Vn2v6ajA7U0)

<https://www.youtube.com/watch?v=Vn2v6ajA7U0>