Solution Review: Problem Challenge 3

We'll cover the following

Count of Structurally Unique Binary Search Trees (hard)#

Given a number 'n', write a function to return the count of structurally unique Binary Search Trees (BST) that can store values 1 to 'n'.

Example 1:

```
Input: 2
Output: 2
Explanation: As we saw in the previous problem, there are 2 uniq
ue BSTs storing numbers from 1-2.
```

Example 2:

```
Input: 3
Output: 5
Explanation: There will be 5 unique BSTs that can store numbers
from 1 to 3.
```

Solution#

This problem is similar to Structurally Unique Binary Search Trees (https://www.educative.io/collection/page/5668639101419520/5671464854355968/5679974795182080/). Following a similar approach, we can iterate from 1 to 'n' and consider each number as the root of a tree and make two recursive calls to count the number of left and right sub-trees.

Code#

Here is what our algorithm will look like:

Java	Python3	C++	JS

```
function count_trees(n) {
  if (n <= 1) {
    return 1;
  }
  let count = 0;
  for (let i = 1; i < n + 1; i++) {
    // making 'i' the root of the tree
    const countOfLeftSubtrees = count_trees(i - 1);
    const countOfRightSubtrees = count_trees(n - i);
    count += (countOfLeftSubtrees * countOfRightSubtrees);
  }
  return count;
}

console.log(`Total trees: ${count_trees(2)}`);
console.log(`Total trees: ${count_trees(3)}`);
```

Run Save Reset

Time complexity#

The time complexity of this algorithm will be exponential and will be similar to Balanced Parentheses (https://www.educative.io/collection/page/5668639101419520/5671464854355968/5753264117121024/). Estimated time complexity will be $O(n * 2^n)$ but the actual time complexity ($O(4^n/\sqrt{n})$) is bounded by the Catalan number (https://en.wikipedia.org/wiki/Catalan_number) and is beyond the scope of a coding interview. See more details here (https://en.wikipedia.org/wiki/Central_binomial_coefficient).

Space complexity#

The space complexity of this algorithm will be exponential too, estimated $O(2^n)$ but the actual will be ($O(4^n/\sqrt{n})$.

Memoized version#

Our algorithm has overlapping subproblems as our recursive call will be evaluating the same sub-expression multiple times. To resolve this, we can use memoization and store the intermediate results in a **HashMap**. In each function call, we can check our map to see if we have already evaluated this sub-expression before. Here is the memoized version of our algorithm, please see highlighted changes:

Java	Python3	C++	JS

```
class TreeNode {
  constructor(val) {
    this.val = val;
    this.left = null;
    this.right = null;
  }
}


function count_trees(n) {
  return count_trees_rec({}, n);
}


function count_trees_rec(map, n) {
  if (n in map) {
    return map[n];
  }

  if (n <= 1) {
    return 1;
  }
  let count = 0;
  for (let i = 1; i < n + 1; i++) {
    // making 'i' the root of the tree
    countOfLeftSubtrees = count_trees_rec(map, i - 1);
    countOfRightSubtrees = count_trees_rec(map, n - i);
    count += (countOfLeftSubtrees * countOfRightSubtrees);
  }

  map[n] = count;
  return count;
}


console.log(`Total trees: ${count_trees(2)}`);
console.log(`Total trees: ${count_trees(3)}`);
```

Run Save Reset

The time complexity of the memoized algorithm will be $O(n^2)$, since we are iterating from '1' to 'n' and ensuring that each sub-problem is evaluated only once. The space complexity will be $O(n)$ for the memoization map.

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Problem Challenge 3

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