Review

- Recursion

- Merge sort
  - Time complexity
  - Memory complexity

Computing Bootcamp

Algorithm Design

Lecture 12

Hyung-Sin Kim

SNU Graduate School of Data Science

Top-down Design Thinking

- Recall function design guideline (Module 2-1-4)
- Understand the given problem
- Think about various ways of solving the problem
- Describe your solution (recipe) logically in human language
- Divide the solution into logical steps
- Translate each logical step into computer language

Technical Interview Process

- Interviewer
  - Describes the problem and shows a few examples
  - Answer interviewee's questions kindly
  - Give feedback to interviewee's solution (optimal or not?) so that they can end up the best solution

- Interviewee
  - Make sure they understand the problem correctly
  - Think what data structure and algorithm to use to solve the problem
  - Solve the problem and **think out loud** so that interviewer can see their thought process
  - Discuss memory overhead and time complexity of the solution
  - Verify if the solution works well by using some test cases

What Companies Want

- Engineers who know what they do and describe it fluently

- “I developed a program and it works. I’m happy! The developing procedure was such a nightmare, I don’t want to go back and read it!” ☹
  - “Well…You can be happy at your home safely. Companies are dangerous for you.”

- “I analyzed the problem, planned what data structures and algorithms to use, analyzed time complexity and memory overhead, verified if it works through some representative test cases. Moreover, I can describe why I chose these data structures and algorithms.” ☺

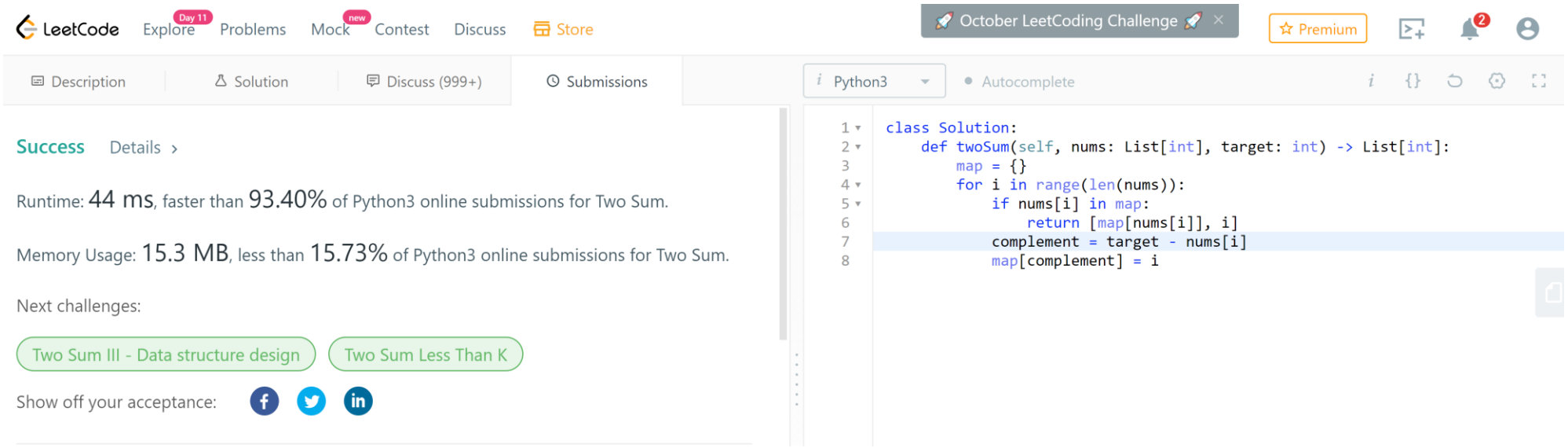
Where We Are

- We just learnt basic data structures and algorithms

- Of course, these are not the end, there are separate courses, data structures and algorithms, offered by DS, CS, and ECE
  - Knowing more of them enables you to solve more problems more efficiently

Practice!

- https://leetcode.com/
  - Famous problems and solutions
  - It evaluates your algorithm, how fast and memory efficient the algorithm is



Example – Two Sum

- https://leetcode.com/problems/two-sum/

Given an array of integers, return **indices** of the two numbers such that they add up to a specific target.

You may assume that each input would have ***exactly*** one solution, and you may not use the *same* element twice.

Example:

```
Given nums = [2, 7, 11, 15], target = 9,

Because nums[0] + nums[1] = 2 + 7 = 9,
return [0, 1].
```

Solutions – Two for loops (1)

- Algorithm design in human language
  - For every number pair in the list,
  - Check if their sum is the given target value
  - If the sum is the target value, return the numbers' indices

Solutions – Two for loops (1)

- Programming in computer language
  - def twoSum(nums: list, target: int) -> list:
    - for i in range(len(nums)):
    - for j in range(len(nums)):
    - if nums[i] + nums[j] == target:
    - return [i, j]

- Performance
  - Time complexity ~ N^2
  - Space complexity ~ 1

Solutions – Two for loops (2)

```
def twoSum(nums: list, target: int) -> list:
    for i in range(len(nums)):
        for j in range(i+1, len(nums)):
            if nums[i] + nums[j] == target:
                return [i, j]
```

- Time complexity ~ $N^2/2$ (slightly better than before)
- Space complexity ~ 1

Solutions – Dictionary (1)

- def twoSum(nums: list, target: int) -> list:
  - **myDict = {}**
  - for i in range(len(nums)): *# Dictionary to find each value's index*
  - myDict[nums[i]] = i
  - for i in range(len(nums):
  - complement = target – nums[i]
  - if complement in myDict: *# Search my complement from the dictionary*
  - return [i, myDict[complement]]

- Time complexity ~ $2N$
- Space complexity ~ N

Solutions – Dictionary (2)

- def twoSum(self, nums: list, target: int) -> list:
  - myDict = {}
  - for i in range(len(nums)):
  - if nums[i] in myDict: *# Did someone select me as its complement?*
  - return [myDict[nums[i]], i]
  - complement = target – nums[i]
  - **myDict[complement] = i** *# Add an entry so that my complement can find my index*

- Time complexity ~ N (slightly better than before)
- Space complexity ~ N

What if the list is sorted?

Solutions – Two Pointers

- def twoSumSorted(self, nums: list, target: int) -> list:
  - i, j = 0, len(nums)-1
  - while nums[i] + nums[j] != target:
  - if nums[i] + nums[j] < target:
  - i = i+1
  - else:
  - j = j-1
  - return [i, j]

- Time complexity ~ N
- Space complexity ~ 1

Thanks!