

ASSIGNMENT - 12.4

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PROMPT:Bubble Sort for Ranking Exam

Scores

You are working on a college result processing system where a small List of student scores needs to be sorted after every internal assessment.

CODE:

```
[1]  ✓ 0s  def bubble_sort_scores(scores):
        n = len(scores)

        # Outer loop: Iterate through the entire list
        for i in range(n):
            # Track if any swap happened in this pass for early termination
            swapped = False

            # Inner loop: Compare adjacent elements
            # The last i elements are already in place, so we ignore them
            for j in range(0, n - i - 1):

                # Comparison: Check if the current score is greater than the next
                if scores[j] > scores[j + 1]:

                    # Swap: If they are in the wrong order, swap them
                    scores[j], scores[j + 1] = scores[j + 1], scores[j]

                    # Mark that a swap occurred
                    swapped = True

            # Early-Termination: If no two elements were swapped by the
            # inner loop, then the list is already sorted.
            if not swapped:
                break

        return scores
```

OUTPUT:

```
[1]  ✓ 0s  # Sample Input: Student Exam Scores
student_scores = [88, 72, 95, 61, 88, 50, 99]

print("Original Scores:", student_scores)
sorted_scores = bubble_sort_scores(student_scores)
print("Sorted Scores: ", sorted_scores)

...
Original Scores: [88, 72, 95, 61, 88, 50, 99]
Sorted Scores:  [50, 61, 72, 88, 88, 95, 99]
```

EXPLANATION:

1. **The "Bubble" Effect:** In every pass through the list, the largest unsorted value "bubbles up" to its correct position at the end of the array.
2. **Passes:** For a list of size n , the algorithm requires at most $n-1$ passes.
3. **Efficiency:** By including the `swapped` flag, we ensure that if the scores are already organized (e.g., after a quick manual entry fix), the code doesn't waste cycles re-checking them.

PROMPT:

Improving Sorting for Nearly Sorted Attendance Records

You are maintaining an attendance system where student roll numbers are already almost sorted, with only a few late updates.

CODE:

```
[2]  ✓ 0s  def bubble_sort(arr):  
    n = len(arr)  
    for i in range(n):  
        swapped = False  
        for j in range(0, n - i - 1):  
            if arr[j] > arr[j + 1]:  
                arr[j], arr[j + 1] = arr[j + 1], arr[j]  
                swapped = True  
        if not swapped:  
            break  
    return arr  
  
def insertion_sort(arr):  
    # Iterate from the second element to the end  
    for i in range(1, len(arr)):  
        key = arr[i] # The "late update" roll number to be placed  
        j = i - 1  
  
        # Move elements of arr[0..i-1] that are greater than the key  
        # to one position ahead of their current position  
        while j >= 0 and key < arr[j]:  
            arr[j + 1] = arr[j]  
            j -= 1  
  
        # Insert the key into its correct sorted position  
        arr[j + 1] = key  
    return arr
```

OUTPUT:

```
[2] ✓ 0s ⏪ # Nearly sorted attendance records (Roll Numbers)
attendance_bubble = [101, 102, 105, 103, 104, 106]
attendance_insertion = [101, 102, 105, 103, 104, 106]

print("Original Records: [101, 102, 105, 103, 104, 106]")
print("Bubble Sort Result: ", bubble_sort(attendance_bubble))
print("Insertion Sort Result:", insertion_sort(attendance_insertion))

...
... Original Records: [101, 102, 105, 103, 104, 106]
Bubble Sort Result: [101, 102, 103, 104, 105, 106]
Insertion Sort Result: [101, 102, 103, 104, 105, 106]
```

EXPLANATION:

- Adaptive Nature: Insertion Sort is "adaptive," meaning it gets faster as the list becomes more sorted. For nearly sorted data, it achieves near $O(n)$ (linear) time, whereas Bubble Sort still struggles with redundant neighbor swaps.
- Less Overhead: While Bubble Sort must constantly swap two elements (requiring 3 steps in memory), Insertion Sort simply shifts elements over to create a gap, which is computationally "cheaper."
- Surgical Precision: Think of it like a librarian. Bubble Sort would swap every book on the shelf one by one to move a single book; Insertion Sort simply picks up the misplaced book and slides it directly into the correct slot.
- Minimal Comparisons: In a nearly sorted list, the "inner loop" of Insertion Sort rarely runs, allowing the algorithm to verify the order in a single quick pass with very few comparisons.

PROMPT:

Searching Student Records in a
Database
Scenario

You are developing a student information portal where users search for student records by roll number.

CODE:

```
[4]  ✓ 0s   def linear_search(records, target):
        for i in range(len(records)):
            if records[i] == target:
                return i # Found at index i
        return -1

    def binary_search(records, target):
        """
        Performs a logarithmic search by repeatedly halving the search interval.

        :param records: A LIST OF SORTED student roll numbers.
        :param target: The roll number to find.
        :return: The index of the target if found, otherwise -1.
        """

        low = 0
        high = len(records) - 1

        while low <= high:
            mid = (low + high) // 2
            if records[mid] == target:
                return mid
            elif records[mid] < target:
                low = mid + 1
            else:
                high = mid - 1

        return -1
```

CODE/OUTPUT:

```
[4]  ✓ 0s   # --- Sample Execution ---
unsorted_data = [105, 120, 101, 115, 110]
sorted_data = [101, 105, 110, 115, 120]
target_roll = 115

print(f"Searching for Roll No: {target_roll}")
print(f"Linear Search (Unsorted Data) Index: {linear_search(unsorted_data, target_roll)}")
print(f"Binary Search (Sorted Data) Index: {binary_search(sorted_data, target_roll)}")

...
... Searching for Roll No: 115
Linear Search (Unsorted Data) Index: 3
Binary Search (Sorted Data) Index: 3
```

EXPLANATION:

- Linear Search is the only option for unsorted data because it checks every record one by one; it is simple but becomes very slow as the database grows.
- Binary Search is extremely fast because it uses a "divide and conquer" approach, cutting the search area in half each step—however, it requires the data to be sorted beforehand to work.
- Performance Gap: For a database of 1,000 students, Linear Search might take 1,000 comparisons, while Binary Search will find any record in just 10 steps ($\log_2 1000 \approx 10$)

PROMPT:

Choosing Between Quick Sort and Merge Sort for Data Processing Scenario

You are part of a data analytics team that needs to sort large datasets received from different sources (random order, already sorted, and reverse sorted).

CODE:

```
▶ import sys

# Increase recursion depth for large/sorted datasets in Quick Sort
sys.setrecursionlimit(2000)

def quick_sort(arr):
    if len(arr) <= 1:
        return arr

    # Selecting the middle element as pivot to handle sorted data better
    pivot = arr[len(arr) // 2]
    left = [x for x in arr if x < pivot]
    middle = [x for x in arr if x == pivot]
    right = [x for x in arr if x > pivot]

    # Recursion: Sort the left and right, then combine
    return quick_sort(left) + middle + quick_sort(right)

def merge_sort(arr):
    if len(arr) <= 1:
        return arr

    # Recursion: split the list into two halves
    mid = len(arr) // 2
    left_half = merge_sort(arr[:mid])
    right_half = merge_sort(arr[mid:])

    # Merge logic: Combine two sorted lists into one
    return merge(left_half, right_half)
```

```

def merge(left, right):
    result = []
    i = j = 0
    while i < len(left) and j < len(right):
        if left[i] < right[j]:
            result.append(left[i])
            i += 1
        else:
            result.append(right[j])
            j += 1
    result.extend(left[i:])
    result.extend(right[j:])
    return result

# --- Testing Scenarios ---
data_variants = {
    "Random": [34, 7, 23, 32, 5, 62],
    "Sorted": [5, 7, 23, 32, 34, 62],
    "Reverse": [62, 34, 32, 23, 7, 5]
}

for name, data in data_variants.items():
    print(f"\n{name} Data: {data}")
    print(f"Quick Sort: {quick_sort(data.copy())}")
    print(f"Merge Sort: {merge_sort(data.copy())}")

```

OUTPUT:

```

...
Random Data: [34, 7, 23, 32, 5, 62]
Quick Sort: [5, 7, 23, 32, 34, 62]
Merge Sort: [5, 7, 23, 32, 34, 62]

Sorted Data: [5, 7, 23, 32, 34, 62]
Quick Sort: [5, 7, 23, 32, 34, 62]
Merge Sort: [5, 7, 23, 32, 34, 62]

Reverse Data: [62, 34, 32, 23, 7, 5]
Quick Sort: [5, 7, 23, 32, 34, 62]
Merge Sort: [5, 7, 23, 32, 34, 62]

```

EXPLANATION:

- Recursive Logic: Both use "Divide and Conquer"; Quick Sort partitions data around a pivot, while Merge Sort focuses on splitting and merging halves consistently.
- Performance: Quick Sort is usually faster in memory (cache-efficient), but Merge Sort is preferred for linked lists or when you need a guaranteed time regardless of whether the data is already sorted or reversed.
- The Difference: While Quick Sort can degrade to $O(n^2)$ if a poor pivot is chosen, Merge Sort never slows down, making it more predictable for critical data pipelines.

PROMPT:

Optimizing a Duplicate Detection

Algorithm

Scenario

You are building a data validation module that must detect duplicate user IDs in a large dataset before importing it into a system.

CODE:

```
[6]  ✓ 0s  ⏪ def find_duplicates_naive(user_ids):
    """
        Brute-force approach using nested loops.
        Compares every ID with every other ID.
    """
    duplicates = []
    for i in range(len(user_ids)):
        for j in range(i + 1, len(user_ids)):
            # If a match is found and it's not already in our duplicate list
            if user_ids[i] == user_ids[j] and user_ids[i] not in duplicates:
                duplicates.append(user_ids[i])
    return duplicates

def find_duplicates_optimized(user_ids):
    """
        Optimized approach using a Set for O(1) average lookup time.
    """
    seen = set()
    duplicates = set()

    for uid in user_ids:
        if uid in seen:
            duplicates.add(uid)
        else:
            seen.add(uid)

    return list(duplicates)
```

```
[6]  ✓ 0s  ⏪ # --- Sample Dataset ---
data = [101, 205, 302, 101, 404, 205, 500]

print(f"Dataset: {data}")
print(f"Naive Result: {find_duplicates_naive(data)}")
print(f"Optimized Result: {find_duplicates_optimized(data)}")

...
Dataset: [101, 205, 302, 101, 404, 205, 500]
Naive Result: [101, 205]
Optimized Result: [205, 101]
```

EXPLANATION:

- The Brute-force ($O(n^2)$) approach is slow because it uses nested loops to compare every ID against every other ID, which becomes unmanageable as data grows.

- The Optimized ($O(n)$) approach is far superior because it uses a Hash Set for near-instant lookups, allowing the algorithm to detect duplicates in a single pass through the dataset