SR UNIVERSITY

AI ASSIST CODING

Lab-21.1: Algorithms with AI Assistance – Sorting, Searching, and Optimizing Algorithms

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Lab Objectives:

Apply AI-assisted programming to implement and optimize sorting and searching algorithms.
• Compare different algorithms in terms of efficiency and use cases. • Understand how AI tools can suggest optimized code and complexity improvements.

Task 1: (Sorting – Merge Sort Implementation)

Prompt : Write a Python program to implement merge sort with proper docstrings.Include time/space complexity analysis and test cases."
Code:

```
def merge_sort(arr):
    """
    Perform Merge Sort on a list of numbers.
Parameters:
        arr (list): List of numbers to be sorted.
    Returns:
        list: Sorted list in ascending order.
    Time Complexity:
```

```
    Best Case: O(n log n)
    Average Case: O(n log n)
    Worst Case: O(n log n)
    Space Complexity:
    O(n) - requires extra space for merging.
  """    if len(arr) <= 1:
return arr    mid = len(arr) // 2
left_half = merge_sort(arr[:mid])
right_half =
merge_sort(arr[mid:])  return
merge(left_half, right_half) def
merge(left, right):
  """Helper function to merge two sorted lists into one sorted list."""
  result = []
  i = j = 0    # Compare elements from left and
right     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
# Add remaining elements (if any)
  result.extend(left[i:])     result.extend(right[j:])     return result
print("Merge Sort Tests:") print(merge_sort([38, 27, 43, 3, 9, 82, 10]))  #
Expected: [3, 9, 10, 27, 38, 43, 82] print(merge_sort([5, 2, 4, 6, 1, 3]))
# Expected: [1, 2, 3, 4, 5, 6] print(merge_sort([1]))                  #
Expected: [1]
print(merge_sort([]))
```

Code Generated:

```python
def merge_sort(arr):
    """
    Perform Merge Sort on a list of numbers.

    Parameters:
        arr (list): List of numbers to be sorted.

    Returns:
        list: Sorted list in ascending order.

    Time Complexity:
        Best Case: O(n log n)
        Average Case: O(n log n)
        Worst Case: O(n log n)

    Space Complexity:
        O(n) - requires extra space for merging.
    """
    if len(arr) <= 1:
        return arr

    mid = len(arr) // 2
    left_half = merge_sort(arr[:mid])
    right_half = merge_sort(arr[mid:])

    return merge(left_half, right_half)


def merge(left, right):
    """Helper function to merge two sorted lists into one sorted list."""
    result = []
    i = j = 0

    # Compare elements from left and right
    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

    # Add remaining elements (if any)
    result.extend(left[i:])
    result.extend(right[j:])
    return result


# ✅ Test cases
print("Merge Sort Tests:")
print(merge_sort([38, 27, 43, 3, 9, 82, 10]))  # Expected: [3, 9, 10, 27, 38, 43, 82]
print(merge_sort([5, 2, 4, 6, 1, 3]))          # Expected: [1, 2, 3, 4, 5, 6]
print(merge_sort([1]))                         # Expected: [1]
print(merge_sort([]))                          # Expected: []
```

Expected Output:

```
PS C:\Users\SANIYA TAHSEEN\OneDrive\Documents\AI_CODING> & "C:/
OneDrive/Documents/AI_CODING/mean.py/merge.py"
Merge Sort Tests:
[3, 9, 10, 27, 38, 43, 82]
[1, 2, 3, 4, 5, 6]
[1]
[]
```

Observations:

- Merge Sort divides the array into halves recursively until single elements remain.
- The merging step combines two sorted halves into a single sorted list.
- Default order is ascending; comparison logic can be inverted for descending.
- Time complexity is consistently O(n log n) in best, average, and worst cases.
- Space complexity is O(n) due to extra lists used in merging.

Task 2: (Searching – Binary Search with AI Optimization)

Prompt : Write a Python program to implement binary search with proper docstrings. Include time/space complexity analysis and test cases.

Code :

```
def binary_search(arr, target):
    """
 Perform Binary Search on a sorted list.
 Parameters:
        arr (list): Sorted list of numbers.
target (int): The number to search for.


    Returns:
        int: Index of the target if found, else -1.
Time Complexity:
        Best Case: O(1)
        Average Case: O(log n)
        Worst Case: O(log n)
     Space Complexity:
        O(1)    """    left,
right = 0, len(arr) - 1
while left <= right:
        mid = (left + right) //
2
        if arr[mid] == target:
            return mid
elif arr[mid] < target:
            left = mid + 1
else:           right =
mid - 1    return -1
```

code generated:

mean.py > binar.py > binary_search

```python
def binary_search(arr, target):
    """
    Perform Binary Search on a sorted list.
    Parameters:
        arr (list): Sorted list of numbers.
        target (int): The number to search for.
    Returns:
        int: Index of the target if found, else -1.
Time Complexity:
        Best Case: O(1)
        Average Case: O(log n)
        Worst Case: O(log n)
    Space Complexity:
        O(1)
    """
    left, right = 0, len(arr) - 1

    while left <= right:
        mid = (left + right) // 2
        if arr[mid] == target:
            return mid
        elif arr[mid] < target:
            left = mid + 1
        else:
            right = mid - 1

    return -1


#  Function calls (test cases)
arr = [1, 3, 5, 7, 9, 11, 13]

print(binary_search(arr, 7))   # Expected output: 3
print(binary_search(arr, 1))   # Expected output: 0
print(binary_search(arr, 13))  # Expected output: 6
print(binary_search(arr, 2))   # Expected output: -1
```

Expected Output:

PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS

```
PS C:\Users\SANIYA TAHSEEN\OneDrive\Documents\AI_CODING> & "C:/Users/SANIYA TAHSEEN/AppData/Local/Programs/Pyt
ts/AI_CODING/mean.py/binar.py"
3
0
6
-1
```

Observations:

- Binary Search is efficient as it halves the search range each step.
- It only works on sorted data.
- Time Complexity → Best: O(1), Worst/Average: O(log n).
- Space Complexity → O(1) (iterative).
- Much faster than linear search for large datasets.
- Limitation: Requires re-sorting if data changes often.

Task 3: (Real-Time Application – InventoryManagement System)

Scenario: A retail store's inventory system contains thousands of products,each with attributes like product ID, name, price, and stock quantity. Store staff need to:

1. Quickly search for a product by ID or name.
2. Sort products by price or quantity for stock analysis.

Prompt :

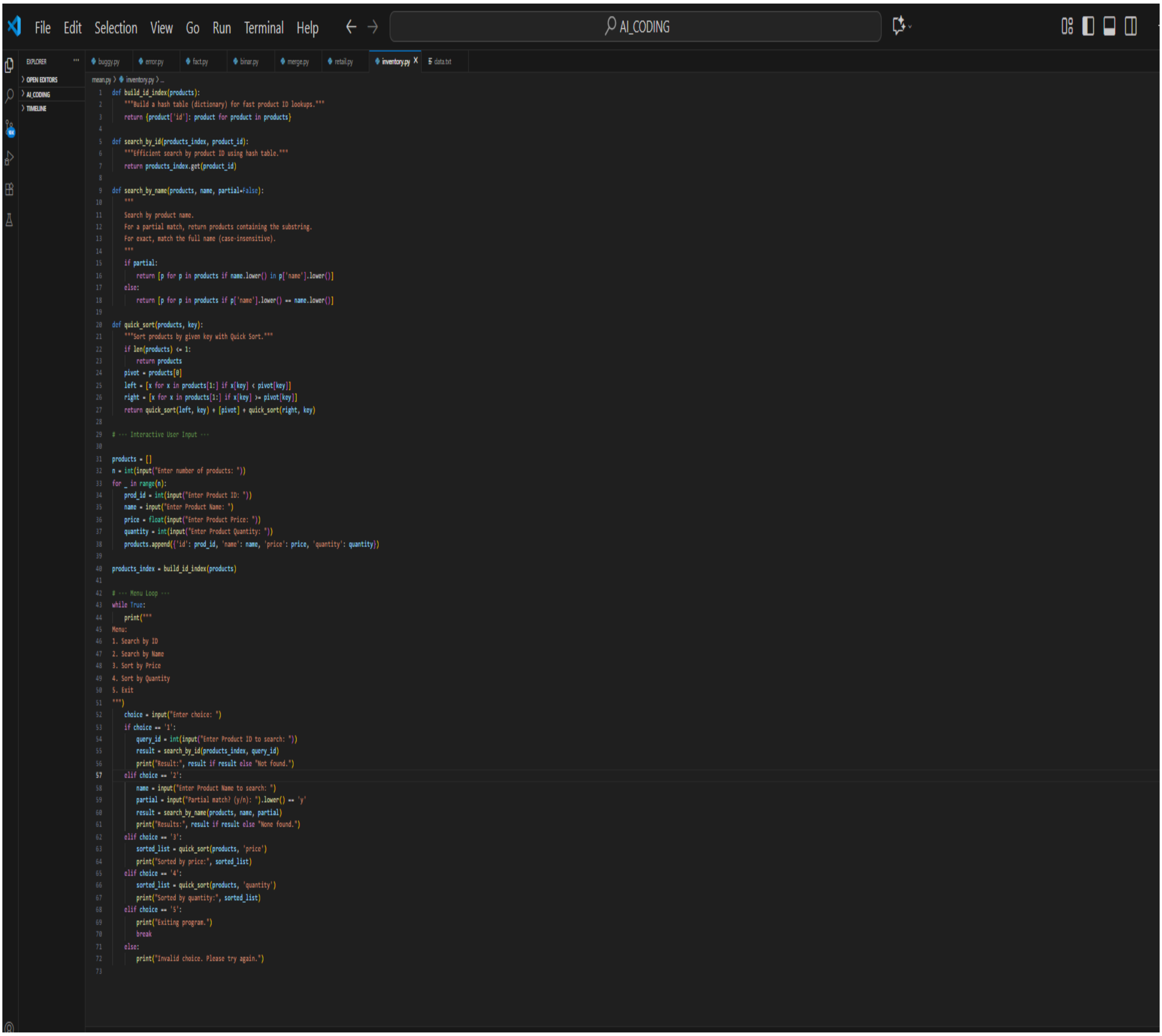
1.implement the recommended algorithms in Python.
2. Justify the choice based on dataset size, update frequency, and performance requirements.

Code:

```
def build_id_index(products):
    """Build a hash table (dictionary) for fast product ID lookups."""
    return {product['id']: product for product in products}

def search_by_id(products_index, product_id):
    """Efficient search by product ID using hash table."""
    return products_index.get(product_id)

def search_by_name(products, name, partial=False):
    """
    Search by product name.
    For a partial match, return products containing the substring.
    For exact, match the full name (case-insensitive).
    """
    if partial:
        return [p for p in products if name.lower() in p['name'].lower()]
    else:
        return [p for p in products if p['name'].lower() == name.lower()]

def quick_sort(products, key):
    """Sort products by given key with Quick Sort."""
    if len(products) <= 1:
        return products
    pivot = products[0]
    left = [x for x in products[1:] if x[key] < pivot[key]]
    right = [x for x in products[1:] if x[key] >= pivot[key]]
    return quick_sort(left, key) + [pivot] + quick_sort(right, key)

# --- Interactive User Input ---

products = []
n = int(input("Enter number of products: "))
for _ in range(n):
```

```
    prod_id = int(input("Enter Product ID: "))
    name = input("Enter Product Name: ")
    price = float(input("Enter Product Price: "))
    quantity = int(input("Enter Product Quantity: "))
    products.append({'id': prod_id, 'name': name, 'price': price, 'quantity': quantity})

products_index = build_id_index(products)

# --- Menu Loop ---
while True:
    print("""
Menu:
1. Search by ID
2. Search by Name
3. Sort by Price
4. Sort by Quantity
5. Exit
""")
    choice = input("Enter choice: ")
    if choice == '1':
        query_id = int(input("Enter Product ID to search: "))
        result = search_by_id(products_index, query_id)
        print("Result:", result if result else "Not found.")
    elif choice == '2':
        name = input("Enter Product Name to search: ")
        partial = input("Partial match? (y/n): ").lower() == 'y'
        result = search_by_name(products, name, partial)
        print("Results:", result if result else "None found.")
    elif choice == '3':
        sorted_list = quick_sort(products, 'price')
        print("Sorted by price:", sorted_list)
    elif choice == '4':
        sorted_list = quick_sort(products, 'quantity')
        print("Sorted by quantity:", sorted_list)
    elif choice == '5':
        print("Exiting program.")
        break
    else:
        print("Invalid choice. Please try again.")
```

Code Generated:




```python
def build_id_index(products):
    """Build a hash table (dictionary) for fast product ID lookups."""
    return {product['id']: product for product in products}

def search_by_id(products_index, product_id):
    """Efficient search by product ID using hash table."""
    return products_index.get(product_id)

def search_by_name(products, name, partial=False):
    """
    Search by product name.
    For a partial match, return products containing the substring.
    For exact, match the full name (case-insensitive).
    """
    if partial:
        return [p for p in products if name.lower() in p['name'].lower()]
    else:
        return [p for p in products if p['name'].lower() == name.lower()]

def quick_sort(products, key):
    """Sort products by given key with Quick Sort."""
    if len(products) <= 1:
        return products
    pivot = products[0]
    left = [x for x in products[1:] if x[key] < pivot[key]]
    right = [x for x in products[1:] if x[key] >= pivot[key]]
    return quick_sort(left, key) + [pivot] + quick_sort(right, key)

# --- Interactive User Input ---

products = []
n = int(input("Enter number of products: "))
for _ in range(n):
    prod_id = int(input("Enter Product ID: "))
    name = input("Enter Product Name: ")
    price = float(input("Enter Product Price: "))
    quantity = int(input("Enter Product Quantity: "))
    products.append({'id': prod_id, 'name': name, 'price': price, 'quantity': quantity})

products_index = build_id_index(products)

# --- Menu Loop ---
while True:
    print("""
Menu:
1. Search by ID
2. Search by Name
3. Sort by Price
4. Sort by Quantity
5. Exit
""")
    choice = input("Enter choice: ")
    if choice == '1':
        query_id = int(input("Enter Product ID to search: "))
        result = search_by_id(products_index, query_id)
        print("Result:", result if result else "Not found.")
    elif choice == '2':
        name = input("Enter Product Name to search: ")
        partial = input("Partial match? (y/n): ").lower() == 'y'
        result = search_by_name(products, name, partial)
        print("Results:", result if result else "None found.")
    elif choice == '3':
        sorted_list = quick_sort(products, 'price')
        print("Sorted by price:", sorted_list)
    elif choice == '4':
        sorted_list = quick_sort(products, 'quantity')
        print("Sorted by quantity:", sorted_list)
    elif choice == '5':
        print("Exiting program.")
        break
    else:
        print("Invalid choice. Please try again.")
```

Expected Output:

```
PROBLEMS    OUTPUT    DEBUG CONSOLE    TERMINAL    PORTS

PS C:\Users\SANIYA TAHSEEN\OneDrive\Documents\AI_CODING> & "C:/Users/SANIYA TAHSEEN/AppData/Local/Programs/Python/Python37/python.exe" "c:/Users/SANIYA TAHSEEN/OneDrive/Documents/AI_CODING/mean.py/inventory.py"
Enter number of products: 3
Enter Product ID: 101
Enter Product Name: Apple
Enter Product Price: 50
Enter Product Quantity: 100
Enter Product ID: 102
Enter Product Name: Grapes
Enter Product Price: 80
Enter Product Quantity: 150
Enter Product ID: 103
Enter Product Name: Banana
Enter Product Price: 20
Enter Product Quantity: 120

Menu:
1. Search by ID
2. Search by Name
3. Sort by Price
4. Sort by Quantity
5. Exit

Enter choice: 1
Enter Product ID to search: 102
Result: {'id': 102, 'name': 'Grapes', 'price': 80.0, 'quantity': 150}

Menu:
1. Search by ID
2. Search by Name
3. Sort by Price
4. Sort by Quantity
5. Exit

Enter choice: 2
Enter Product Name to search: Apple
Partial match? (y/n): n
Results: [{'id': 101, 'name': 'Apple', 'price': 50.0, 'quantity': 100}]

Menu:
1. Search by ID
2. Search by Name
3. Sort by Price
4. Sort by Quantity
5. Exit

Enter choice: 3
Sorted by price: [{'id': 103, 'name': 'Banana', 'price': 20.0, 'quantity': 120}, {'id': 101, 'name': 'Apple', 'price': 50.0, 'quantity': 100}, {'id': 102, 'name': 'Grapes', 'price': 80.0, 'quantity': 150}]

Menu:
1. Search by ID
2. Search by Name
3. Sort by Price
4. Sort by Quantity
5. Exit

Enter choice: 4
Sorted by quantity: [{'id': 101, 'name': 'Apple', 'price': 50.0, 'quantity': 100}, {'id': 103, 'name': 'Banana', 'price': 20.0, 'quantity': 120}, {'id': 102, 'name': 'Grapes', 'price': 80.0, 'quantity': 150}]
```

```
Menu:
1. Search by ID
2. Search by Name
3. Sort by Price
4. Sort by Quantity
5. Exit

Enter choice: 5
Exiting program.
```

Observations:

- Hash tables provide lightning-fast search by product ID using constant-time lookups.
- Partial substring search enables flexible name queries, helping find products by any part of their name.
- Quick Sort delivers efficient sorting by price or quantity with average $O(n \log n)$ time complexity.
- Interactive menu-driven design allows real-time product input, searching, and sorting by store staff.