

Inventory Track Pro: Smart Inventory Management System

Data Structures and Algorithms Project Report

Project Title: Inventory Track Pro: Smart Inventory Management System

Group Members:

1. Gul Ahmed (24-SE-100)
2. Khurram Sohail (24-SE-72)
3. Mudassar Hussain (24-SE-40)

Course: Data Structures and Algorithms Lab

Institution: University of Engineering and Technology Taxila

Submission Date: December 2025

1.0 Introduction

Inventory Track Pro is a console-based inventory management system that implements core DSA concepts for efficient product management. The system combines multiple data structures to provide fast operations, dynamic sorting, and data persistence.

Objectives:

- Demonstrate practical application of DSA concepts
- Provide efficient inventory management operations
- Implement robust error handling and data validation
- Enable data persistence through file I/O

2.1 Data Structures Used

| Data Structure | Purpose | Key Operations |
|--------------------|--------------------|-----------------------------|
| Hash Table | Primary storage | O(1) search/insert/delete |
| Binary Search Tree | Range queries | O(log n) price range search |
| Arrays | Sorting operations | Merge Sort & Quick Sort |
| Stacks | Undo/Redo | Action history tracking |
| File I/O | Data persistence | Save/load inventory |

3.0 Key Features

3.1 Product Management

- **Add Product:** Validates and stores new products
- **Search Product:** Fast lookup using hash table
- **Update Product:** Modify existing product details
- **Delete Product:** Remove products with confirmation

3.2 Advanced Operations

- **Sorting:** By price, rating, or sales (ascending/descending)
- **Range Search:** Find products within price range
- **Undo/Redo:** Revert/redo last operations
- **File Operations:** Save/load from CSV files

3.3 Error Handling

- Input validation for all data types
- Range checking for numerical values
- File error handling and recovery
- User-friendly error messages

4.0 Implementation Details

4.1 Data Structures

```
struct Product {  
    string id, name, category;  
    double price, rating;  
    int stock, sales;  
};  
  
struct HashNode {  
    Product product;  
    HashNode* next;  
};  
  
struct BSTNode {  
    Product product;  
    BSTNode* left, *right;  
};
```

4.2 Key Algorithms

Hash Function:

```
int hashFunction(string id) {  
    int hash = 0;  
    for (int i = 0; i < id.length(); i++) {  
        hash = hash * 31 + id[i];  
    }  
    return abs(hash) % 100;  
}
```

Sorting Algorithms:

- **Merge Sort:** Stable, $O(n \log n)$
- **Quick Sort:** In-place, $O(n \log n)$ average

Range Search: Modified BST in-order traversal

5.0 Performance Analysis

5.1 Time Complexity

| Operation | Average Case | Worst Case |
|-------------------|-----------------|---------------|
| Add/Search/Delete | $O(1)$ | $O(n)$ |
| Update | $O(1)$ | $O(n)$ |
| Range Search | $O(\log n + k)$ | $O(n)$ |
| Sorting | $O(n \log n)$ | $O(n \log n)$ |
| Undo/Redo | $O(1)$ | $O(1)$ |

5.2 Space Complexity

- Hash Table: $O(n)$
- BST: $O(n)$
- Arrays: $O(n)$ temporary
- Stacks: $O(m)$ operations
- **Total:** $O(n)$ linear

6.0 Testing Results

6.1 Functional Testing

- ✓ Add product with validation
- ✓ Search existing/non-existent products
- ✓ Update product information
- ✓ Delete with confirmation
- ✓ Sort by all criteria
- ✓ Range search functionality
- ✓ Undo/redo operations
- ✓ File save/load operations

6.2 Error Testing

- ✓ Invalid input handling
- ✓ Out-of-range values
- ✓ Duplicate ID prevention
- ✓ File error recovery
- ✓ Memory management

7.0 User Interface

Main Menu Interface

```
○ PS D:\University\DSA_LAB\project_DSA> cd "d:\University\DSA_LAB\project_DSA\" ;  
ct }  
=====  
INVENTORY TRACK PRO - DSA PROJECT  
=====  
  
== INVENTORY TRACK PRO ==  
1. Add Product  
2. Search Product  
3. Update Product  
4. Delete Product  
5. Display All Products  
6. Sort Products  
7. Range Search by Price  
8. Undo Last Operation  
9. Redo Last Operation  
10. Save to File  
11. Load from File  
12. Exit  
=====  
Enter your choice (1-12): 1  
  
== ADD NEW PRODUCT ==  
Enter Product ID: 001  
Enter Product Name: Laptop  
Enter Category: Electronic  
Enter Price: $200  
Enter Rating (0-5): 4  
Enter Stock: 10  
Enter Sales: 4  
Product added successfully!
```

```
=====
Enter your choice (1-12): 5

== ALL PRODUCTS ==
ID      Name           Category     Price    Rating  Stock   Sales
-----
001    Laptop          Electronic   $200.00  4.0    10     4
-----
Total Products: 1
```

Random Data Added :

```
001,Wireless Headphones,Electronics,129.99,4.3,45,300
002,Blender,Kitchen Appliances,79.99,4.1,23,187
003,Yoga Mat,Fitness,34.50,4.7,82,415
004,Coffee Maker,Home Appliances,89.99,4.5,18,256
005,Running Shoes,Sports,119.99,4.2,67,522
006,Desk Lamp,Home Decor,42.75,4.4,52,198
007,Leather Wallet,Fashion,29.99,4.8,124,743
008,Board Game,Entertainment,49.99,4.6,36,89
009,Backpack,Travel,64.99,4.0,41,210
010,Plant Pot,Garden,24.50,4.9,88,331
```

```
=====
Enter your choice (1-12): 5

== ALL PRODUCTS ==
ID      Name           Category     Price    Rating  Stock   Sales
-----
001    Wireless Headphones  Electronics  $129.99  4.3    45     300
002    Blender            Kitchen Appliances  $79.99  4.1    23     187
003    Yoga Mat           Fitness        $34.50  4.7    82     415
004    Coffee Maker        Home Appliances  $89.99  4.5    18     256
005    Running Shoes       Sports         $119.99  4.2    67     522
006    Desk Lamp           Home Decor     $42.75  4.4    52     198
007    Leather Wallet      Fashion        $29.99  4.8    124    743
008    Board Game           Entertainment  $49.99  4.6    36     89
009    Backpack            Travel         $64.99  4.0    41     210
010    Plant Pot           Garden        $24.50  4.9    88     331
-----
Total Products: 10
```

Search Operation Results:

```
=====
Enter your choice (1-12): 2

=== SEARCH PRODUCT ===
Enter Product ID to search: 004

Product Found:
ID: 004
Name: Coffee Maker
Category: Home Appliances
Price: $89.99
Rating: 4.5
Stock: 18
Sales: 256
```

Sorting Products by Price:

```
=====
Enter your choice (1-12): 6

=== SORT PRODUCTS ===

=== SORT OPTIONS ===
Sort by:
1. Price
2. Rating
3. Sales
Enter your choice (1-3): 1

=== SORTING ALGORITHM ===
1. Merge Sort
2. Quick Sort
Enter your choice (1-2): 1

=== SORT ORDER ===
1. Ascending
2. Descending
Enter your choice (1-2): 1

Sorted using Merge Sort:

ID      Name        Price   Rating Stock   Sales
-----  -----
010    Plant Pot    $24.50  4.9    88     331
007    Leather Wallet $29.99  4.8    124    743
003    Yoga Mat     $34.50  4.7    82     415
006    Desk Lamp    $42.75  4.4    52     198
008    Board Game   $49.99  4.6    36     89
009    Backpack     $64.99  4.0    41     210
002    Blender       $79.99  4.1    23     187
004    Coffee Maker $89.99  4.5    18     256
005    Running Shoes $119.99 4.2    67     522
001    Wireless Headphones $129.99 4.3    45     300
```

Range Search Results

```
=====
Enter your choice (1-12): 7

==== RANGE SEARCH BY PRICE ===
Enter minimum price: $24
Enter maximum price: $40

==== PRODUCTS IN PRICE RANGE $24.0 to $40.0 ===
ID: 010 Name: Plant Pot Price: $24.5
ID: 007 Name: Leather Wallet Price: $30.0
ID: 003 Name: Yoga Mat Price: $34.5
```

Undo Operation Demonstration: Deleting 001 product and Undoing it.

```
=====
Enter your choice (1-12): 4

==== DELETE PRODUCT ===
Enter Product ID to delete: 001
Are you sure you want to delete product '001'? (y/n): y
Product deleted successfully!
```

```
=====
Enter your choice (1-12): 5

==== ALL PRODUCTS ===
ID      Name           Category     Price    Rating   Stock   Sales
-- 
002    Blender        Kitchen Appliances $79.99  4.1     23     187
003    Yoga Mat       Fitness        $34.50   4.7     82     415
004    Coffee Maker   Home Appliances $89.99   4.5     18     256
005    Running Shoes  Sports         $119.99  4.2     67     522
006    Desk Lamp      Home Decor    $42.75   4.4     52     198
007    Leather Wallet Fashion        $29.99   4.8     124    743
008    Board Game     Entertainment $49.99   4.6     36     89
009    Backpack       Travel        $64.99   4.0     41     210
010    Plant Pot      Garden       $24.50   4.9     88     331
-- 
Total Products: 9
```

```
=====
Enter your choice (1-12): 8
Product added successfully!
Undo operation completed!
```

```
=====
Enter your choice (1-12): 5

==== ALL PRODUCTS ===
ID      Name           Category     Price   Rating Stock Sales
-----+
001    Wireless Headphones Electronics $129.99 4.3    45   300
002    Blender          Kitchen Appliances $79.99 4.1    23   187
003    Yoga Mat         Fitness        $34.50 4.7    82   415
004    Coffee Maker     Home Appliances $89.99 4.5    18   256
005    Running Shoes   Sports        $119.99 4.2    67   522
006    Desk Lamp        Home Decor    $42.75 4.4    52   198
007    Leather Wallet  Fashion       $29.99 4.8    124  743
008    Board Game       Entertainment $49.99 4.6    36   89
009    Backpack         Travel        $64.99 4.0    41   210
010    Plant Pot        Garden       $24.50 4.9    88   331
-----+
Total Products: 10
```

File Save Operation

```
=====
Enter your choice (1-12): 10

==== SAVE TO FILE ====
Enter filename to save (e.g., products.txt): ProdustData.txt
Successfully saved 10 products to ProdustData.txt
```

8.0 Advantages

1. **Efficiency:** O(1) operations using hash table
2. **Flexibility:** Multiple sorting options
3. **Reliability:** Comprehensive error handling
4. **Usability:** Undo/redo functionality
5. **Persistence:** File-based data storage
6. **Scalability:** Handles up to 1000 products

9.0 Limitations & Future Work

9.1 Current Limitations

- Fixed hash table size (100 buckets)
- BST can degrade with sorted input
- Console-based interface only

- Single-criterion sorting

9.2 Future Enhancements

1. **Data Structures:** Dynamic hash table, AVL tree
2. **Features:** Multi-field search, statistics
3. **Interface:** Graphical user interface
4. **Performance:** Caching, indexing
5. **Advanced:** Network support, APIs

10.0 Conclusion

Inventory Track Pro successfully demonstrates practical implementation of DSA concepts in inventory management. The system provides efficient operations through hybrid data structure usage while maintaining robustness through comprehensive error handling.

Key Achievements:

- Practical application of hash tables, BST, sorting algorithms
- Efficient product management operations
- User-friendly interface with error recovery
- Complete data persistence solution

The project serves as an excellent foundation for more advanced inventory systems and demonstrates the importance of appropriate data structure selection for specific operations.