Bubble Sort Algorithm

Introduction

Bubble Sort is one of the simplest sorting algorithms. It repeatedly steps through the list, compares adjacent elements, and swaps them if they are in the wrong order. This process is repeated until the list is sorted. Although not efficient for large datasets, it is a great algorithm for understanding the basics of sorting.

Algorithm Steps

1. Start with the first element in the list.
2. Compare the current element with the next element.
3. If the current element is greater than the next element, swap them.
4. Move to the next element and repeat the comparison until the end of the list.
5. Repeat the entire process for the remaining elements, reducing the comparison range each time.
6. Stop when no swaps are needed in a complete pass through the list.

Python Code

Here is a Python implementation of the Bubble Sort algorithm:

```python
def bubble_sort(arr):
    n = len(arr)
    for i in range(n):
        # Flag to detect if any swaps were made
        swapped = False
        for j in range(0, n - i - 1):
            if arr[j] > arr[j + 1]:
                # Swap the elements
                arr[j], arr[j + 1] = arr[j + 1], arr[j]
                swapped = True
        # If no swaps were made, the array is sorted
        if not swapped:
            break
    return arr

# Example usage
numbers = [64, 34, 25, 12, 22, 11, 90]
print("Unsorted List:", numbers)
sorted_numbers = bubble_sort(numbers)
print("Sorted List:", sorted_numbers)
```

Time Complexity

- **Best Case (Already Sorted List)**: O(n)
- **Average Case**: O(n^2)
- **Worst Case (Reverse Sorted List)**: O(n^2)

Space Complexity

- **Auxiliary Space**: O(1) (in-place sorting)

Visualization

Unsorted List: [64, 34, 25, 12, 22, 11, 90]

Pass 1: [34, 25, 12, 22, 11, 64, 90]
Pass 2: [25, 12, 22, 11, 34, 64, 90]
Pass 3: [12, 22, 11, 25, 34, 64, 90]
Pass 4: [12, 11, 22, 25, 34, 64, 90]
Pass 5: [11, 12, 22, 25, 34, 64, 90]

Advantages

1. Simple and easy to understand.
2. Suitable for small datasets.

Disadvantages

1. Inefficient for large datasets.
2. High time complexity compared to more advanced algorithms like Quick Sort or Merge Sort.

Conclusion

Bubble Sort is a basic sorting algorithm that is useful for educational purposes. While it may not be practical for sorting large datasets, understanding its implementation and optimization is an important step in learning about algorithms.