

Bubble Sort

February 2, 2014

Bubble Sort is the simplest sorting algorithm that works by repeatedly swapping the adjacent elements if they are in wrong order.

Example:

First Pass:

(**5** 1 4 2 8) \rightarrow (**1** 5 4 2 8), Here, algorithm compares the first two elements, and swaps since $5 > 1$.

(**1** 5 4 2 8) \rightarrow (**1** 4 5 2 8), Swap since $5 > 4$

(**1** 4 5 2 8) \rightarrow (**1** 4 2 5 8), Swap since $5 > 2$

(**1** 4 2 5 8) \rightarrow (**1** 4 2 5 8), Now, since these elements are already in order ($8 > 5$), algorithm does not swap them.

Second Pass:

(**1** 4 2 5 8) \rightarrow (**1** 4 2 5 8)

(**1** 4 2 5 8) \rightarrow (**1** 2 4 5 8), Swap since $4 > 2$

(**1** 2 4 5 8) \rightarrow (**1** 2 4 5 8)

(**1** 2 4 5 8) \rightarrow (**1** 2 4 5 8)

Now, the array is already sorted, but our algorithm does not know if it is completed. The algorithm needs one **whole** pass without **any** swap to know it is sorted.

Third Pass:

(**1** 2 4 5 8) \rightarrow (**1** 2 4 5 8)

(**1** 2 4 5 8) \rightarrow (**1** 2 4 5 8)

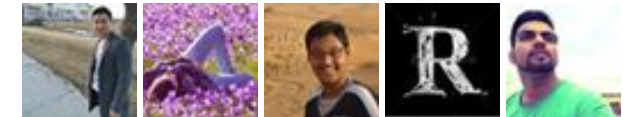
(**1** 2 4 5 8) \rightarrow (**1** 2 4 5 8)



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(1 2 4 5 8) -> (1 2 4 5 8)

Following is C implementation of Bubble Sort.

```
// C program for implementation of Bubble sort
#include <stdio.h>
```

```
void swap(int *xp, int *yp)
{
    int temp = *xp;
    *xp = *yp;
    *yp = temp;
}
```

```
// A function to implement bubble sort
void bubbleSort(int arr[], int n)
{
    int i, j;
    for (i = 0; i < n; i++)
        for (j = 0; j < n-i-1; j++) //Last i elements are already in
            if (arr[j] > arr[j+1])
                swap(&arr[j], &arr[j+1]);
}
```

```
/* Function to print an array */
void printArray(int arr[], int size)
{
    int i;
    for (i=0; i < size; i++)
        printf("%d ", arr[i]);
    printf("\n");
}
```

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```
// Driver program to test above functions
int main()
{
    int arr[] = {64, 34, 25, 12, 22, 11, 90};
    int n = sizeof(arr)/sizeof(arr[0]);
    bubbleSort(arr, n);
    printf("Sorted array: \n");
    printArray(arr, n);
    return 0;
}
```

Output:

```
Sorted array:
11 12 22 25 34 64 90
```

Optimized Implementation:

The above function always runs $O(n^2)$ time even if the array is sorted. It can be optimized by stopping the algorithm if inner loop didn't cause any swap.

```
// Optimized implementation of Bubble sort
#include <stdio.h>
```

```
void swap(int *xp, int *yp)
{
    int temp = *xp;
    *xp = *yp;
    *yp = temp;
}
```

```
// An optimized version of Bubble Sort
void bubbleSort(int arr[], int n)
{
    int i, j;
    bool swapped;
    for (i = 0; i < n; i++)
    {
        swapped = false;
        for (j = 0; j < n-i-1; j++)
        {
            if (arr[j] > arr[j+1])
            {
                swap(&arr[j], &arr[j+1]);
                swapped = true;
            }
        }
    }
}
```

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```

    }
}

// IF no two elements were swapped by inner loop, then break
if (swapped == false)
    break;
}
}

/* Function to print an array */
void printArray(int arr[], int size)
{
    int i;
    for (i=0; i < size; i++)
        printf("%d ", arr[i]);
    printf("\n");
}

// Driver program to test above functions
int main()
{
    int arr[] = {64, 34, 25, 12, 22, 11, 90};
    int n = sizeof(arr)/sizeof(arr[0]);
    bubbleSort(arr, n);
    printf("Sorted array: \n");
    printArray(arr, n);
    return 0;
}

```

Output:

Sorted array:

11 12 22 25 34 64 90

Time Complexity: $O(n^2)$

Auxiliary Space: $O(1)$

Boundary Cases: Bubble sort takes minimum time (Order of n) when elements are already sorted.

Sorting In Place: Yes

Stable: Yes

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Due to its simplicity, bubble sort is often used to introduce the concept of a sorting algorithm. In computer graphics it is popular for its capability to detect a very small error (like swap of just two elements) in almost-sorted arrays and fix it with just linear complexity ($2n$). For example, it is used in a polygon filling algorithm, where bounding lines are sorted by their x coordinate at a specific scan line (a line parallel to x axis) and with incrementing y their order changes (two elements are swapped) only at intersections of two lines (Source: [Wikipedia](#))

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