Bubble Sort Algorithm

In this tutorial, you will learn how bubble sort works. Also, you will find working examples of bubble sort in C, C++, Java and Python.

Bubble sort is an algorithm that compares the adjacent elements and swaps their positions if they are not in the intended order. The order can be ascending or descending.

How Bubble Sort Works?

1. Starting from the first index, compare the first and the second elements.If the first element is greater than the second element, they are swapped.

   Now, compare the second and the third elements. Swap them if they are not in order.

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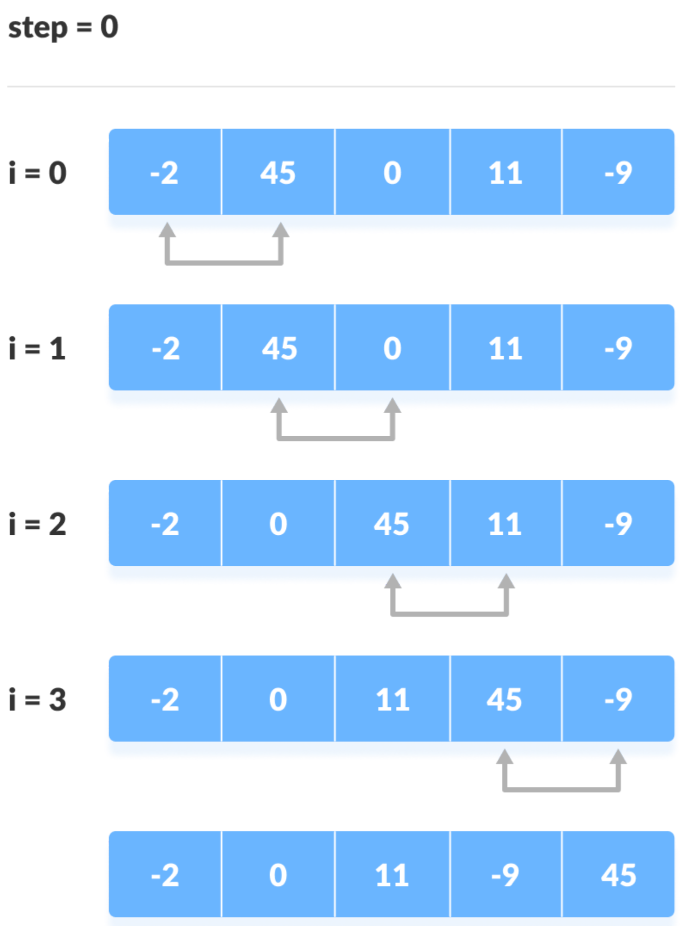
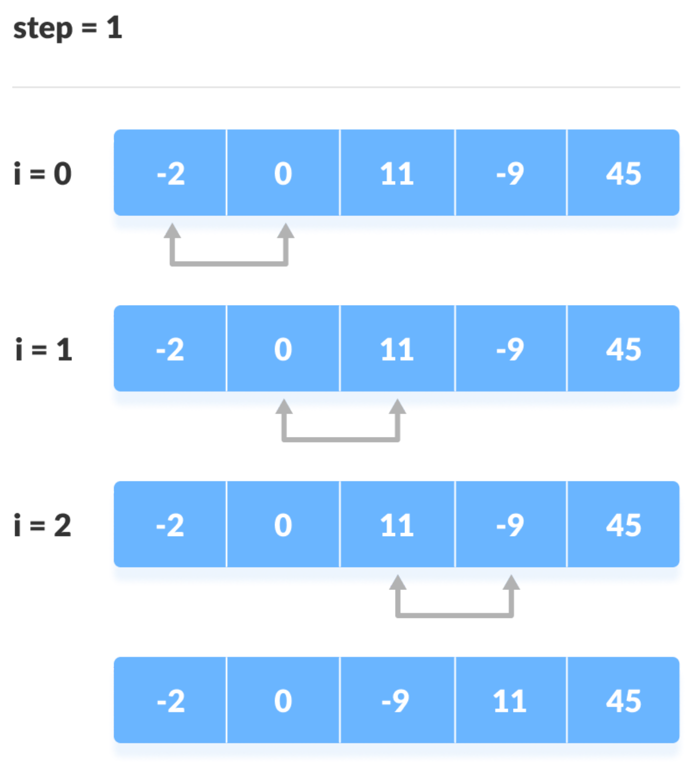
The above process goes on until the last element.



2. The same process goes on for the remaining iterations. After each iteration, the largest element among the unsorted elements is placed at the end.

   In each iteration, the comparison takes place up to the last unsorted element.

   The array is sorted when all the unsorted eleme' Contents ' their correct positions.



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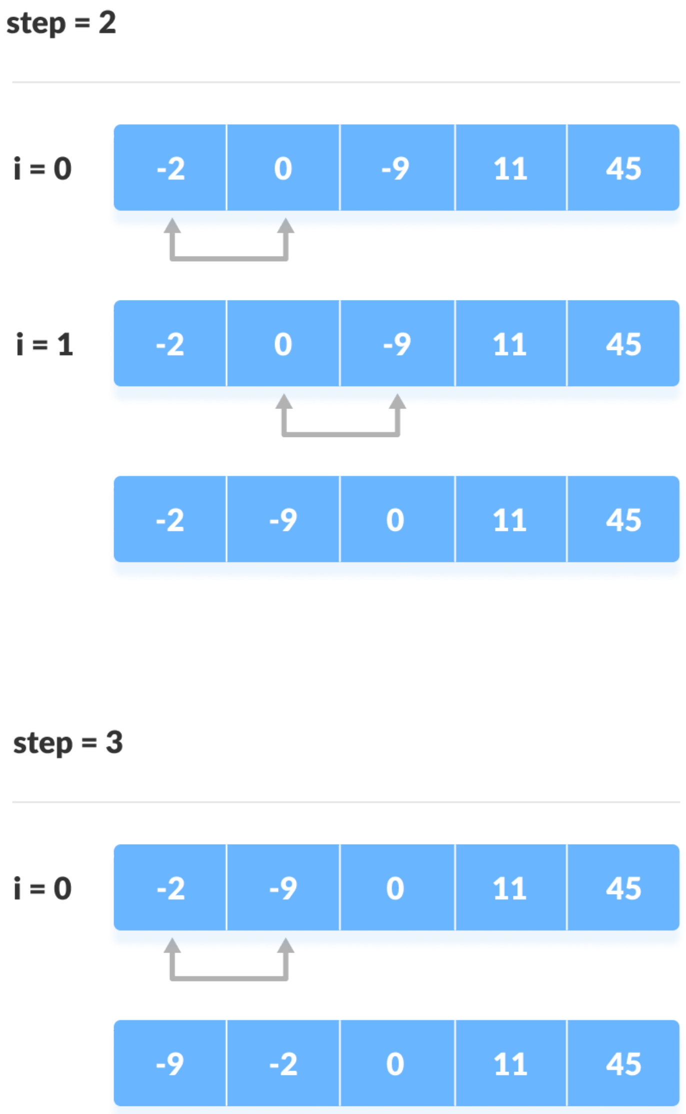

Bubble Sort Algorithm

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```
bubbleSort(array)
  for i <- 1 to indexOfLastUnsortedElement-1
    if leftElement > rightElement
      swap leftElement and rightElement
end bubbleSort
```

Python, Java and C/C++ Examples

Python Java C C+

```
# Bubble sort in Python

def bubbleSort(array):
    for i in range(len(array)):
        for j in range(0, len(array) - i - 1):

            # To sort in descending order, change > to < in this line.

            if array[j] > array[j + 1]:
                (array[j], array[j + 1]) = (array[j + 1], array[j])


data = [-2, 45, 0, 11, -9]
bubbleSort(data)
print('Sorted Array in Ascending Order:')
print(data)
```

Optimized Bubble Sort

In the above code, all possible comparisons are mac Contents array is already sorted. It increases the execution time.

The code can be optimized by introducing an extra variable `swapped`. After each iteration, if there is no swapping taking place then, there is no need for performing further loops.

In such case, variable `swapped` is set false. Thus, we can prevent further iterations.

Algorithm for optimized bubble sort is

```
bubbleSort(array)
  swapped <- false
  for i <- 1 to indexOfLastUnsortedElement-1
    if leftElement > rightElement
      swap leftElement and rightElement
      swapped <- true
end bubbleSort
```

Optimized Bubble Sort Examples

Python Java C C+

```
# Python Program To Sort data in ascending order using bubble sort.

def bubbleSort(array):
    for i in range(len(array)):
        swapped = True
        for j in range(0, len(array) - i - 1):

            # To sort in descending order, change > to < in this line.

            if array[j] > array[j + 1]:
                (array[j], array[j + 1]) = (array[j + 1], array[j])
                swapped = False
                if swapped == True:
                    break
```

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```
data = [-2, 45, 0, 11, -9]
bubbleSort(data)
print('Sorted Array in Ascending Order:')
print(data)
```

Complexity

Bubble Sort is one of the simplest sorting algorithms. Two loops are implemented in the algorithm.

Cycle	Number of Comparisons
1st	(n-1)
2nd	(n-2)
3rd	(n-3)
....	......
last	1

Number of comparisons: `(n-1) + (n-2) + (n-3) +.....+ 1 = n(n-1)/2` nearly equals to n^2

Complexity: $O(n^2)$

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Also, we can analyze the complexity by simply observing the number of loops. There are 2 loops so the complexity is `n*n = n`^{2}

Time Complexities:

- **Worst Case Complexity:** `O(n`^{2}`)`

  If we want to sort in ascending order and the array is in descending order then, the worst case occurs.

- **Best Case Complexity:** `O(n)`

  If the array is already sorted, then there is no need for sorting.

- **Average Case Complexity:** `O(n`^{2}`)`

  It occurs when the elements of the array are in jumbled order (neither ascending nor descending).

Space Complexity:

Space complexity is `O(1)` because an extra variable `temp` is used for swapping.

In the optimized algorithm, the variable `swapped` adds to the space complexity thus, making it `O(2)` .

Bubble Sort Applications

Bubble sort is used in the following cases where

1. the complexity of the code does not matter.
2. a short code is preferred.

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