Bubble Sort

In this tutorial, you will learn about the bubble sort algorithm and its implementation in Python, Java, C, and C++.

Bubble sort is a sorting algorithm that compares two adjacent elements and swaps them until they are in the intended order.

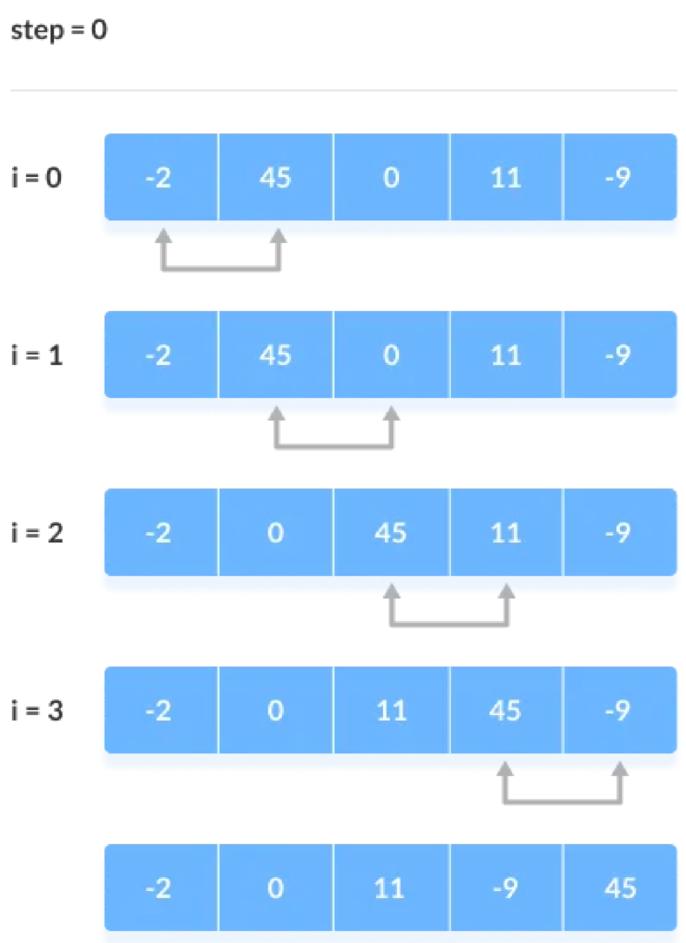
Just like the movement of air bubbles in the water that rise up to the surface, each element of the array move to the end in each iteration. Therefore, it is called a bubble sort.

Working of Bubble Sort

Suppose we are trying to sort the elements in **ascending order**.

1. First Iteration (Compare and Swap)

1. Starting from the first index, compare the first and the second elements.
2. If the first element is greater than the second element, they are swapped.
3. Now, compare the second and the third elements. Swap them if they are not in order.
4. The above process goes on until the last element.

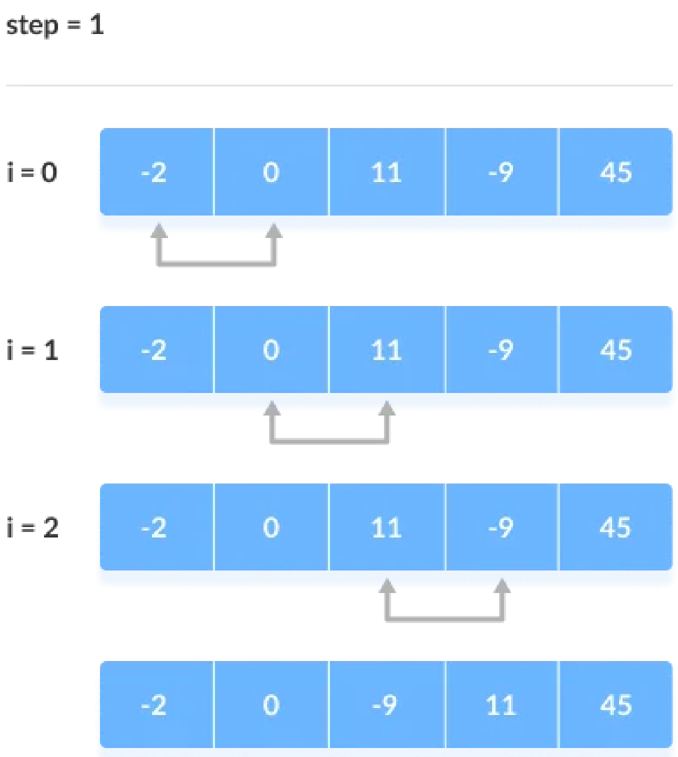


Compare the Adjacent Elements

2. Remaining Iteration

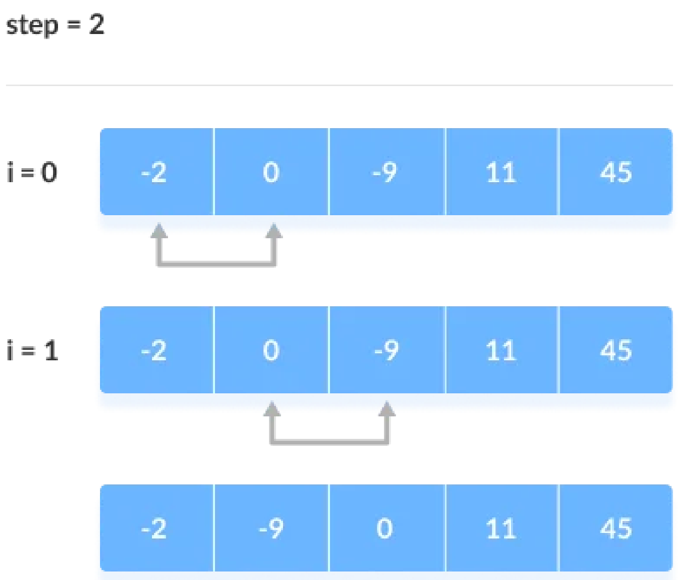
The same process goes on for the remaining iterations.

After each iteration, the largest element among the unsorted elements is placed at the end.



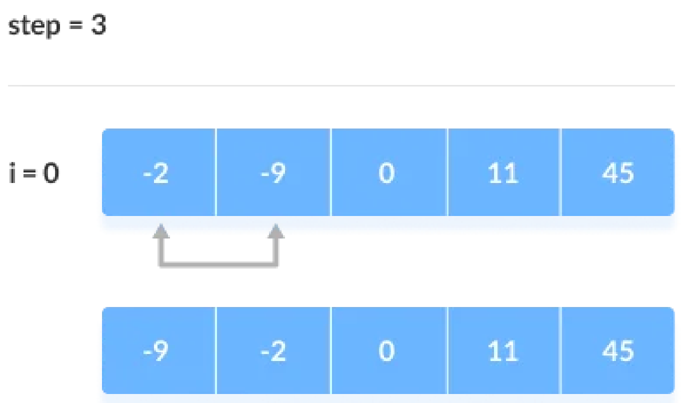
Put the largest element at the end

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



Compare the adjacent elements

The array is sorted when all the unsorted elements are placed at their correct positions.



The array is sorted if all elements are kept in the right order

Bubble Sort Algorithm

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

Bubble Sort Code in Python, Java and C/C++

Python Java C C++

```
// Bubble sort in C

#include <stdio.h>

// perform the bubble sort
void bubbleSort(int array[], int size) {

  // loop to access each array element
  for (int step = 0; step < size - 1; ++step) {

    // loop to compare array elements
    for (int i = 0; i < size - step - 1; ++i) {

      // compare two adjacent elements
      // change > to < to sort in descending order
      if (array[i] > array[i + 1]) {

        // swapping occurs if elements
        // are not in the intended order
        int temp = array[i];
        array[i] = array[i + 1];
        array[i + 1] = temp;
      }
    }
  }
}

// print array
```

Optimized Bubble Sort Algorithm

In the above algorithm, all the comparisons are made even if the array is already sorted.

This increases the execution time.

To solve this, we can introduce an extra variable `swapped`. The value of `swapped` is set true if there occurs swapping of elements. Otherwise, it is set **false**.

After an iteration, if there is no swapping, the value of `swapped` will be **false**. This means elements are already sorted and there is no need to perform further iterations.

This will reduce the execution time and helps to optimize the bubble sort.

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 in Python, Java, and C/C++

Python Java C C++

```
// Optimized Bubble sort in C

#include

// perform the bubble sort
void bubbleSort(int array[], int size) {

  // loop to access each array element
  for (int step = 0; step < size - 1; ++step) {

    // check if swapping occurs
    int swapped = 0;

    // loop to compare array elements
    for (int i = 0; i < size - step - 1; ++i) {

      // compare two array elements
      // change > to < to sort in descending order
      if (array[i] > array[i + 1]) {

        // swapping occurs if elements
        // are not in the intended order
        int temp = array[i];
        array[i] = array[i + 1];
        array[i + 1] = temp;

        swapped = 1;
      }
```

Bubble Sort Complexity

Time Complexity	
Best	O(n)
Worst	O(n^2)
Average	O(n^2)
Space Complexity	O(1)
Stability	Yes

Complexity in Detail

Bubble Sort compares the adjacent elements.

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

Hence, the number of comparisons is

```
(n-1) + (n-2) + (n-3) +.....+ 1 = n(n-1)/2
```

nearly equals to n^2

Hence, **Complexity:** $O(n^2)$

Also, if we observe the code, bubble sort requires two loops. Hence, the complexity is $n*n = n^2$

1. 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).

2. Space Complexity

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

- In the **optimized bubble sort algorithm**, two extra variables are used. Hence, the space complexity will be `O(2)`.

Bubble Sort Applications

Bubble sort is used if

- complexity does not matter
- short and simple code is preferred