Insertion Sort

Insertion sort is a simple sorting algorithm that works similar to the way you sort playing cards in your hands. The array is virtually split into a sorted and an unsorted part. Values from the unsorted part are picked and placed at the correct position in the sorted part.

Characteristics of Insertion Sort:

- This algorithm is one of the simplest algorithm with simple implementation
- Basically, Insertion sort is efficient for small data values
- Insertion sort is adaptive in nature, i.e. it is appropriate for data sets which are already partially sorted.

Working of Insertion Sort algorithm:

Consider an example: arr[]: {12, 11, 13, 5, 6}

12 11 13 5 6

First Pass:

- *Initially, the first two elements of the array are compared in insertion sort.*

12	***11***	*13*	*5*	*6*

- *Here, 12 is greater than 11 hence they are not in the ascending order and 12 is not at its correct position. Thus, swap 11 and 12.*
- *So, for now 11 is stored in a sorted sub-array.*

11	***12***	*13*	*5*	*6*

Second Pass:

- *Now, move to the next two elements and compare them*

11	***12***	***13***	*5*	*6*

- *Here, 13 is greater than 12, thus both elements seems to be in ascending order, hence, no swapping will occur. 12 also stored in a sorted sub-array along with 11*

Third Pass:

- *Now, two elements are present in the sorted sub-array which are **11** and **12***
- *Moving forward to the next two elements which are 13 and 5*

11	*12*	***13***	***5***	*6*

- *Both 5 and 13 are not present at their correct place so swap them*

11	*12*	***5***	***13***	*6*

- *After swapping, elements 12 and 5 are not sorted, thus swap again*

11	***5***	***12***	*13*	*6*

- *Here, again 11 and 5 are not sorted, hence swap again*

5	***11***	*12*	*13*	*6*

- *here, it is at its correct position*

Fourth Pass:

- *Now, the elements which are present in the sorted sub-array are **5, 11** and **12***
- *Moving to the next two elements 13 and 6*

5	*11*	*12*	***13***	***6***

- *Clearly, they are not sorted, thus perform swap between both*

5	*11*	*12*	***6***	***13***

- *Now, 6 is smaller than 12, hence, swap again*

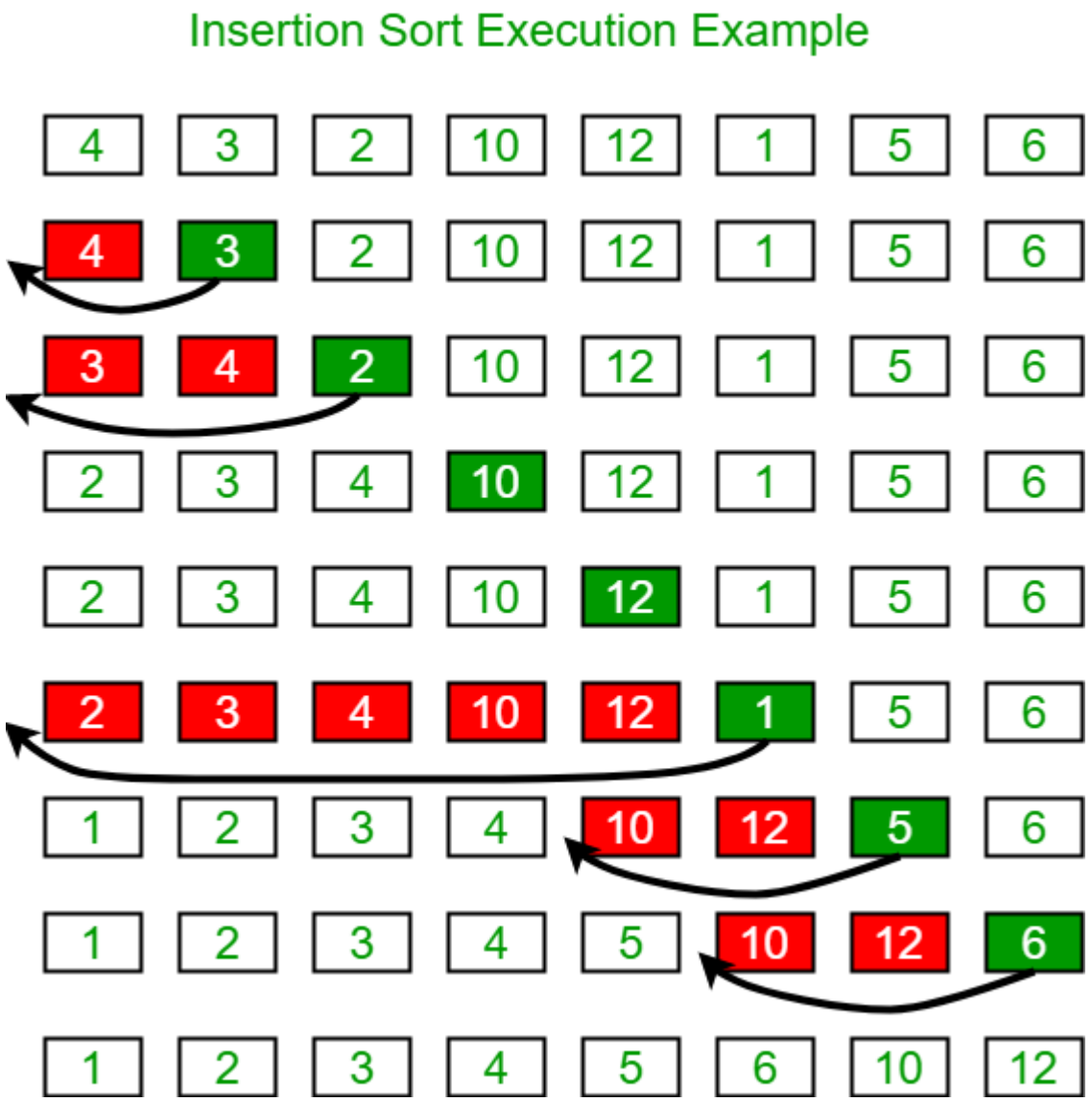
5	*11*	***6***	***12***	*13*

- *Here, also swapping makes 11 and 6 unsorted hence, swap again*

5	***6***	***11***	*12*	*13*

- *Finally, the array is completely sorted.*

Illustrations:



Insertion Sort Algorithm

To sort an array of size N in ascending order:

- Iterate from arr[1] to arr[N] over the array.
- Compare the current element (key) to its predecessor.
- If the key element is smaller than its predecessor, compare it to the elements before. Move the greater elements one position up to make space for the swapped element.

Implementation

C++Java

```
// C++ program for insertion sort
```

```cpp
#include <bits/stdc++.h>
using namespace std;

// Function to sort an array using
// insertion sort
void insertionSort(int arr[], int n)
{
    int i, key, j;
    for (i = 1; i < n; i++)
    {
        key = arr[i];
        j = i - 1;

        // Move elements of arr[0..i-1],
        // that are greater than key, to one
        // position ahead of their
        // current position
        while (j >= 0 && arr[j] > key)
        {
            arr[j + 1] = arr[j];
            j = j - 1;
        }
        arr[j + 1] = key;
    }
}

// A utility function to print an array
// of size n
void printArray(int arr[], int n)
{
    int i;
    for (i = 0; i < n; i++)
        cout << arr[i] << " ";
    cout << endl;
}

// Driver code
int main()
```

```
{
    int arr[] = { 12, 11, 13, 5, 6 };
    int N = sizeof(arr) / sizeof(arr[0]);

    insertionSort(arr, N);
    printArray(arr, N);

    return 0;
}
// This is code is contributed by rathbhupendra
```

Output

```
5 6 11 12 13
```

Time **Complexity:** O(N^2)

Auxiliary Space: O(1)

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