Computer Science >

Arrays and Sorting: Insertion Sort (with C Program source code)

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Insertion sort

Insertion sort uses linear search to find the location of the 1st element in the unsorted list, in the sorted portion of the list. It is an elementary sorting algorithm best used to sort small data sets or insert a new element in the sorted list.

Algorithm:

Insertion sort starts with a sorted list of size 1 and inserts elements one at a time. It continues inserting each successive element into the sorted list so far.
1. Suppose if the array is sorted till index i then we can sort the array till i+1 by inserting the (i+1)th element in the correct position from 0 to i+1.
2. The position at which (i+1)th element has to be inserted has to be found by iterating from 0 to i.
3. As any array is sorted till 0th position (Single element is always sorted) and we know how to expand, we can sort the whole array.

To check out a Java Applet Visualization of Insertion Sort, click on the image below :

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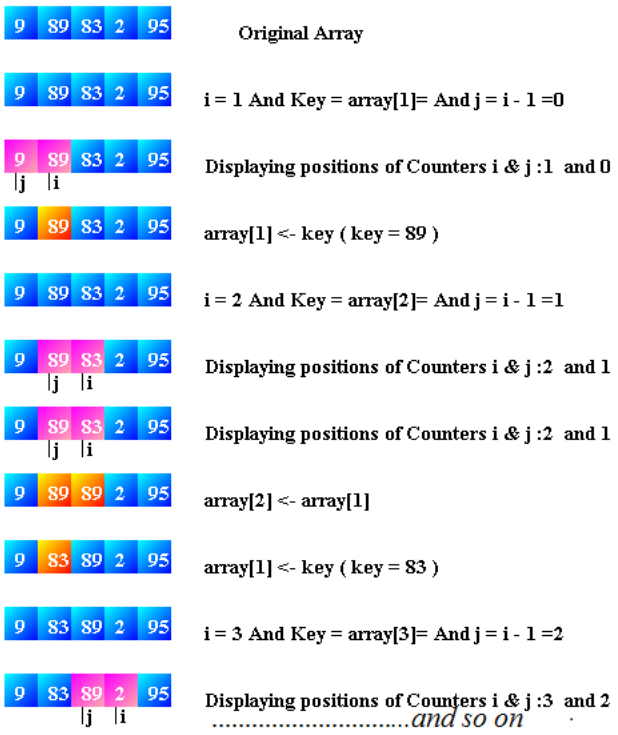
Insertion Sort

```
for i -> 0 to lastIndex - 1
 key = array[i] , j = i-1
 while(j >=0 && array[j]>key )
  array[j+1] <- array[j]
array[j]<- key ;
next i
```



Properties:

1. Best case performance – When the array is already sorted O(n). Total number of comparisons: N – 1 and total number of exchanges: N – 1.
2. Worst case performance – When the array is sorted in reverse order O(n2). N-1 iterations of comparison and exchanges.
3. Average case performance – O(n2)
4. It is sensitive to the input as the number of comparison and exchanges depends on the input.
5. It does not require any extra space for sorting, hence O(1) extra space.

Tutorial :

Insertion sort

Insertion sort uses linear search to find the location of the 1st element in the unsorted list, in the sorted portion of the list. It is an elementary sorting algorithm best used to sort small data sets or insert a new element in the sorted list.

Algorithm:

Insertion sort starts with a sorted list of size 1 and inserts elements one at a time. It continues inserting each successive element into the sorted list so far.

1. Suppose if the array is sorted till index i then we can sort the array till i+1 by inserting $i+1^{th}$ element in the correct position from 0 to i+1.
2. The position at which $(i+1)^{th}$ element has to be inserted has to be found by iterating from 0 to i.
3. As any array is sorted till 0th position (Single element is always sorted) and we know how to expand, we can sort the whole array.

Property:

1. Best case performance – When the array is already sorted O(n). Total number of comparisons: N – 1 and total number of exchanges: N – 1.
2. Worst case performance – When the array is sorted in reverse order $O(n^2)$. N-1 iterations of comparison and exchanges.
3. Average case performance – $O(n^2)$
4. It is sensitive to the input as the number of comparison and exchanges depends on the input.
5. It does not require any extra space for sorting, hence O(1) extra space

Insertion Sort - C Program Source Code

```
#include<stdio.h>
/* Logic : Suppose if the array is sorted till index i then we can sort the arry till i+1 by inserting
           i+1 th element in the correct position from 0 to i+1. The position at which (i+1)th element has
           to be inserted has to be found by iterating from 0 to i. As any array is sorted till 0th postion
           (Single element is always sorted) and we know how to expand, we can sort the whole array
 */
void InsertionSort(int *array , int number_of_elements)
{
        int iter,jter;
        for(iter=1;iter<number_of_elements;iter++)
        {
                int current_element = array[iter];
                jter = iter-1;
                while(jter>=0 && array[jter] > current_element)
                {
                        array[jter+1] = array[jter];
                        jter--;
                }
                array[jter+1] = current_element;
        }
}
int main()
{
        int number_of_elements;
        scanf("%d",&number_of_elements);
        int array[number_of_elements];
        int iter;
        for(iter = 0;iter < number_of_elements;iter++)
        {
                scanf("%d",&array[iter]);
        }
        /* Calling this functions sorts the array */
        InsertionSort(array,number_of_elements);
        for(iter = 0;iter < number_of_elements;iter++)
```

```
        {
                printf("%d ",array[iter]);
        }
        printf("\n");
        return 0;
}
```

Related Tutorials :

Bubble Sort	One of the most elementary sorting algorithms to implement - and also very inefficient. Runs in quadratic time. A good starting point to understand sorting in general, before moving on to more advanced techniques and algorithms. A general idea of how the algorithm works and a the code for a C program.	Insertion Sort	Another quadratic time sorting algorithm - an example of dynamic programming. An explanation and step through of how the algorithm works, as well as the source code for a C program which performs insertion sort.	Selection Sort	Another quadratic time sorting algorithm - an example of a greedy algorithm. An explanation and step through of how the algorithm works, as well as the source code for a C program which performs selection sort.	Shell Sort	An inefficient but interesting algorithm, the complexity of which is not exactly known.	Merge Sort	An example of a Divide and Conquer algorithm. Works in O(n log n) time. The memory complexity for this is a bit of a disadvantage.	Quick Sort	In the average case, this works in O(n log n) time. No additional memory overhead - so this is better than merge sort in this regard. A partition element is selected, the array is restructured such that all elements greater or less than the partition are on opposite sides of the partition. These two parts of the array are then sorted recursively.	Heap Sort	Efficient sorting algorithm which runs in O(n log n) time. Uses the Heap data structure.	Binary Search Algorithm	C us al us th of el a s ar in tir

Some Important Data Structures and Algorithms, at a glance:

Arrays : Popular Sorting and Searching Algorithms			
Bubble Sort	Insertion Sort	Selection Sort	Shell Sort
Merge Sort	Quick Sort	Heap Sort	Binary Search Algorithm
Basic Data Structures and Operations on them			
Stacks	Queues	Single Linked List	Double Linked List
Circular Linked List	1.		

Tree Data			

Structures			
Binary Search Trees	**Heaps**	**Height Balanced Trees**	
Graphs and Graph Algorithms			
Depth First Search	**Breadth First Search**	**Minimum Spanning Trees: Kruskal Algorithm**	**Minumum Spanning Trees: Prim's Algorithm**
Dijkstra Algorithm for Shortest Paths	**Floyd Warshall Algorithm for Shortest Paths**	**Bellman Ford Algorithm**	
Popular Algorithms in Dynamic Programming			
Dynamic Programming	**Integer Knapsack problem**	**Matrix Chain Multiplication**	**Longest Common Subsequence**
Greedy Algorithms			
Elementary cases : Fractional Knapsack Problem, Task Scheduling	**Data Compression using Huffman Trees**		

insertion.png (33k) Prashant Bhattacharji, Oct **v.4**