Heap Sort Algorithm

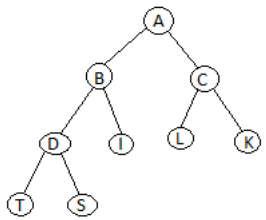
Heap Sort is one of the best sorting methods being in-place and with no quadratic worst-case scenarios. Heap sort algorithm is divided into two basic parts :

- Creating a Heap of the unsorted list.
- Then a sorted array is created by repeatedly removing the largest/smallest element from the heap, and inserting it into the array. The heap is reconstructed after each removal.

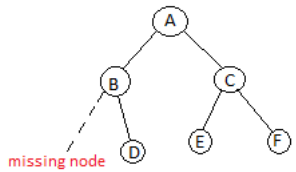
What is a Heap ?

Heap is a special tree-based data structure, that satisfies the following special heap properties :

1. **Shape Property :** Heap data structure is always a Complete Binary Tree, which means all levels of the tree are fully filled.



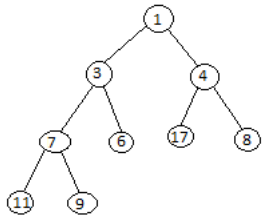
Complete Binary Tree



In-Complete Binary Tree

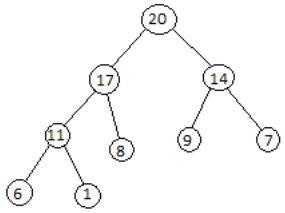
2. **Heap Property :** All nodes are either *[greater than or equal to]* or *[less than or equal to]* each of its children. If the parent nodes are greater than their children, heap is called a **Max-Heap**, and if the parent nodes are smalled than their child nodes, heap is called **Min-Heap**.

Coming Soon



Min-Heap

In min-heap, first element is the smallest. So when we want to sort a list in ascending order, we create a Min-heap from that list, and picks the first element, as it is the smallest, then we repeat the process with remaining elements.



Max-Heap

In max-heap, the first element is the largest, hence it is used when we need to sort a list in descending order.

How Heap Sort Works

Initially on receiving an unsorted list, the first step in heap sort is to create a Heap data structure(Max-Heap or Min-Heap). Once heap is built, the first element of the Heap is either largest or smallest(depending upon Max-Heap or Min-Heap), so we put the first element of the heap in our array. Then we again make heap using the remaining elements, to again pick the first element of the heap and put it into the array. We keep on doing the same repeatedly untill we have the complete sorted list in our array.

In the below algorithm, initially **heapsort()** function is called, which calls **buildheap()** to build heap, which inturn uses **satisfyheap()** to build the heap.

Sorting using Merge Sort Algorithm

```
/*  Below program is written in C++ language  */

void heapsort(int[], int);
void buildheap(int [], int);
void satisfyheap(int [], int, int);

void main()
{
  int a[10], i, size;
  cout << "Enter size of list";    // less than 10, because max size of array is 10
  cin >> size;
  cout << "Enter" << size << "elements";
  for( i=0; i < size; i++)
  {
    cin >> a[i];
  }
  heapsort(a, size);
  getch();
}

void heapsort(int a[], int length)
```

```
{
  buildheap(a, length);
  int heapsize, i, temp;
  heapsize = length - 1;
  for( i=heapsize; i >= 0; i--)
  {
    temp = a[0];
    a[0] = a[heapsize];
    a[heapsize] = temp;
    heapsize--;
    satisfyheap(a, 0, heapsize);
  }
  for( i=0; i < length; i++)
  {
    cout << "\t" << a[i];
  }
}

void buildheap(int a[], int length)
{
  int i, heapsize;
  heapsize = length - 1;
  for( i=(length/2); i >= 0; i--)
  {
    satisfyheap(a, i, heapsize);
  }
}

void satisfyheap(int a[], int i, int heapsize)
{
  int l, r, largest, temp;
  l = 2*i;
  r = 2*i + 1;
  if(l <= heapsize && a[l] > a[i])
  {
    largest = l;
  }
  else
  {
    largest = i;
  }
  if( r <= heapsize && a[r] > a[largest])
  {
    largest = r;
  }
  if(largest != i)
  {
    temp = a[i];
    a[i] = a[largest];
    a[largest] = temp;
    satisfyheap(a, largest, heapsize);
  }
}
```

Complexity Analysis of Heap Sort

Worst Case Time Complexity : O(n log n)

Best Case Time Complexity : O(n log n)

Average Time Complexity : O(n log n)

Space Complexity : O(n)

- Heap sort is not a Stable sort, and requires a constant space for sorting a list.
- Heap Sort is very fast and is widely used for sorting.

← Prev (merge-sort)

Next → (stack-data-structure)