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TimSort

TimSort is a sorting algorithm based on Insertion Sort and Merge Sort.

1. A stable sorting algorithm works in O(n Log n) time
2. Used in Java's Arrays.sort() as well as Python's sorted() and sort().
3. First sort small pieces using Insertion Sort, then merges the pieces using merge of merge sort.

We divide the Array into blocks known as **Run**. We sort those runs using insertion sort one by one and then merge those runs using combine function used in merge sort. If the size of Array is less than run, then Array get sorted just by using Insertion Sort. The size of run may vary from 32 to 64 depending upon the size of the array. Note that merge function performs well when sizes subarrays are powers of 2. The idea is based on the fact that insertion sort performs well for small arrays.

Recommended: Please try your approach on *{IDE}* first, before moving on to the solution.

Details of below implementation :

- We consider size of run as 32.
- We one by one sort pieces of size equal to run
- After sorting individual pieces, we merge them one by one. We double the size of merged subarrays after every iteration.

C++ | Java | Python3 | C#

```java
// Java program to perform TimSort.
class GFG
{
    static int RUN = 32;

    // this function sorts array from left index to
    // to right index which is of size atmost RUN
    public static void insertionSort(int[] arr, int left, int right)
    {
        for (int i = left + 1; i <= right; i++)
        {
            int temp = arr[i];
            int j = i - 1;
            while (arr[j] > temp && j >= left)
            {
                arr[j + 1] = arr[j];
                j--;
            }
            arr[j + 1] = temp;
        }
    }

    // merge function merges the sorted runs
    public static void merge(int[] arr, int l,
                             int m, int r)
    {
        // original array is broken in two parts
        // left and right array
        int len1 = m - l + 1, len2 = r - m;
        int[] left = new int[len1];
        int[] right = new int[len2];
        for (int x = 0; x < len1; x++)
        {
            left[x] = arr[l + x];
        }
        for (int x = 0; x < len2; x++)
        {
            right[x] = arr[m + 1 + x];
        }

        int i = 0;
        int j = 0;
        int k = l;

        // after comparing, we merge those two array
        // in larger sub array
        while (i < len1 && j < len2)
        {
            if (left[i] <= right[j])
            {
                arr[k] = left[i];
                i++;
            }
            else
            {
                arr[k] = right[j];
                j++;
            }
```


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```
            k++;
        }

        // copy remaining elements of left, if any
        while (i < len1)
        {
            arr[k] = left[i];
            k++;
            i++;
        }

        // copy remaining element of right, if any
        while (j < len2)
        {
            arr[k] = right[j];
            k++;
            j++;
        }
    }

    // iterative Timsort function to sort the
    // array[0...n-1] (similar to merge sort)
    public static void timSort(int[] arr, int n)
    {

        // Sort individual subarrays of size RUN
        for (int i = 0; i < n; i += RUN)
        {
            insertionSort(arr, i, Math.min((i + 31), (n - 1)));
        }

        // start merging from size RUN (or 32). It will merge
        // to form size 64, then 128, 256 and so on ....
        for (int size = RUN; size < n; size = 2 * size)
        {

            // pick starting point of left sub array. We
            // are going to merge arr[left..left+size-1]
            // and arr[left+size, left+2*size-1]
            // After every merge, we increase left by 2*size
            for (int left = 0; left < n; left += 2 * size)
            {

                // find ending point of left sub array
                // mid+1 is starting point of right sub array
                int mid = left + size - 1;
                int right = Math.min((left + 2 * size - 1), (n - 1));

                // merge sub array arr[left.....mid] &
                // arr[mid+1....right]
                merge(arr, left, mid, right);
            }
        }
    }

    // utility function to print the Array
    public static void printArray(int[] arr, int n)
    {
        for (int i = 0; i < n; i++)
        {
            System.out.print(arr[i] + " ");
        }
        System.out.print("\n");
    }

    // Driver code
    public static void main(String[] args)
    {
        int[] arr = {5, 21, 7, 23, 19};
        int n = arr.length;
        System.out.print("Given Array is\n");
        printArray(arr, n);

        timSort(arr, n);

        System.out.print("After Sorting Array is\n");
        printArray(arr, n);
    }
}

// This code has been contributed by 29AjayKumar
```

Output:

```
Given Array is
5  21  7  23  19
After Sorting Array is
5  7  19  21  23
```

References :

https://svn.python.org/projects/python/trunk/Objects/listsort.txt

https://en.wikipedia.org/wiki/Timsort#Minimum_size_.28minrun.29

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