Lecture # 09

Date: Sept 16, 25 Day: Tuesday

Linear Sorting Algorithms

→ non-comparison based algo...

if majority of elements in the array is already sorted : Insertion sort

→ Counting Sort (Linear time)

constraints:

1. Small range
   out of place & stable.

>=
< =

comparison base sorting

if range is larger ; we will not use counting sort bcz T(n) will be in exponential (inefficient)...

2	5	3	0	2	3	0	3
1	2	3	4	5	6	7	8

range = 0 – 5

1. Create an array (frequencies) → size = max of the array.
   → stores frequency of each element

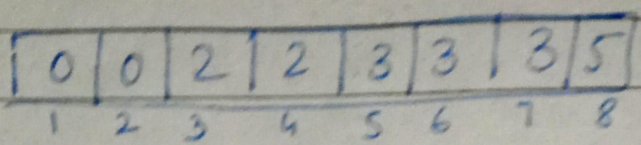
2	0	2	3	0	1
0	1	2	3	4	5

x2. Copy the elements ...

2. Compute the compulative frequencies → to make it stable.
   update the freq array with it..

2	2	4	7	7	8
0	1	2	3	4	5

Arr[i] += Arr[i-1] → last occurance of '3' in the array



* if time complexity depends on the values of the data :- pseudo polynomials

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```
CountingSort ( data [1 ... N]) {

1)   K = getMax (data);          — N
     freq [0 ---- k] = {0}       — 1

2)   for ( i = 1 to N)           — N   // count freq of each elem
       freq [data [i]]++ ;

3)   for ( i = 1 to k)           — K
       freq [i] += freq [i-1]

     for i = N down to 1         — N   (to make it a stable algorithm)
       Res [freq [data[i]]] = data[i]
       freq [data[i]] -- ;
```

$T(N) = O(N+k)$

Date: Day:

if there are -ive values in the array; we will pick the minimum value and add them into the values ----

2	-5	3	0	2	3	0	-3

min = -5 ↓ add krein

7	0	8	5	7	8	5	2

Sort krein

0	2	5	5	7	7	8	8

-5 ↓ subtract krein

-5	-3	0	0	2	2	3	3

Radix Sort

25109

* digit level sorting , units - tens - thousands ...

329	720	720	329
457	355	329	355
657	436	436	436
839	457	839	457
436	657	355	657
720	329	457	720
355	839	657	839

Date:

* should be stable for it to work

63 → 61 63 67

* now freq of 6 is 3, if not stable then sorting incorrect

for (i = N downto 1)

```
CountSort ( Arr [1...N], dpos, N) {

    freq [0...9] = {0}
    for (i = 1 to N) {                          - O(N)
        freq [(Arr[i]/dpos) % 10] ++
    }
    for i = 1 to 9 {                            - O(1)
        freq[i] += freq[i-1] }

    res [1...N]
    for (i = N down to 1) {                     - O(N)
        res [freq [(Arr[i]/dpos) % 10]] = Arr[i]
        freq [(Arr[i]/dpos) % 10] --
    }
    //copy res into original arr                - O(N)
}

RadixSort ( Arr [1...N], N) {

    max = getMax (Arr, N)
    for (dpos = 1; max/dpos > 0; dpos *= 10)
        CountSort (Arr, dpos, N)
}
```

Date:

→ $O(d * (N + K))$

$K = 9$

* linear time

* if $d = N$, we have number with same no. of digits as input size, then

$O(N^2)$ → not linear anymore

* if num of digits in input is fixed, like sorting CNICs, tel nums, then radix sort