**Tugas 2 : Analisis Kompleksitas Waktu**

**Counting Sort**

Mata Kuliah : Analisis Algoritma



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1. **Algoritma Kerja**

Terdapat array A dengan n adalah 8, maka dibutuhkan array C dimana array dengan rentan nilai setiap A[i] adalah 1 sampai 6

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| A | 3 | 6 | 4 | 1 | 3 | 4 | 1 | 4 |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| C | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |

Pengurutan dilakukan secara linier dengan menelusuri array A, dengan proses sebagi berikut

**Langkah 1 :** Pembacaan array pertama. A[1] berisi angka 3, maka C[3] ditambah 1

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| A | 3 | 6 | 4 | 1 | 3 | 4 | 1 | 4 |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| C | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |

**Langkah 2 :**  Pembacaan array kedua. A[2] berisi angka 6, maka C[6] ditambah 1

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| A | 3 | 6 | 4 | 1 | 3 | 4 | 1 | 4 |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| C | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |

Langkah 3 : Pembacaan array ketiga. A[3] berisi angka 4. maka C[4] ditambah 1

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| A | 3 | 6 | 4 | 1 | 3 | 4 | 1 | 4 |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| C | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |

Langkah 4 : pembacaan array keempat. A[4] berisi angka 1. maka C[1] ditambah 1

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| A | 3 | 6 | 4 | 1 | 3 | 4 | 1 | 4 |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| C | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 0 |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |

Langkah 5 : Pembacaan array kelima. A[5] berisi angka 3. maka C[3] ditambah 1

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| A | 3 | 6 | 4 | 1 | 3 | 4 | 1 | 4 |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| C | 1 | 0 | 2 | 1 | 0 | 1 | 0 | 0 |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |

Langkah 6 : Pembacaan array kelima. A[6] berisi angka 4. maka C[4] ditambah 1

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| A | 3 | 6 | 4 | 1 | 3 | 4 | 1 | 4 |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| C | 1 | 0 | 2 | 2 | 0 | 1 | 0 | 0 |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |

Langkah 7 : Pembacaan array kelima. A[7] berisi angka 1. maka C[1] ditambah 1

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| A | 3 | 6 | 4 | 1 | 3 | 4 | 1 | 4 |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| C | 2 | 0 | 2 | 2 | 0 | 1 | 0 | 0 |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |

Langkah 8 : Pembacaan array kelima. A[8] berisi angka 4. maka C[4] ditambah 1

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| A | 3 | 6 | 4 | 1 | 3 | 4 | 1 | 4 |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| C | 2 | 0 | 2 | 3 | 0 | 1 | 0 | 0 |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |

Semua elemen A sudah dibaca. sehingga didapat array C sebagai berikut

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| C | 2 | 0 | 2 | 3 | 0 | 1 | 0 | 0 |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |

Kemudian array C diproses sehingga tiap elemen C, C[i] tidak merepresentasikan jumlah elemen dengan nilai sama dengan I, namun setiap C[i] adalah jumlah elemen yang lebih kecil atau sama dengan i. yaitu dengan menambahkan array dengan array seanjutnya

Langkah 1 : array 1 dijumlahkan dengan array 2

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| C | 2 | 0 | 2 | 3 | 0 | 1 | 0 | 0 |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| C | 2 | 2 | 2 | 3 | 0 | 1 | 0 | 0 |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |

Langkah 2 : array 2 dijumlahkan dengan array 3

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| C | 2 | 2 | 4 | 3 | 0 | 1 | 0 | 0 |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |

Langkah 3 : array 3 dijumlahkan dengan array 4

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| C | 2 | 2 | 4 | 7 | 0 | 1 | 0 | 0 |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |

Langkah 4 : array 4 dijumlahkan dengan array 5

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| C | 2 | 2 | 4 | 7 | 7 | 1 | 0 | 0 |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |

Langkah 5 : array 5 dijumlahkan dengan array 6

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| C | 2 | 2 | 4 | 7 | 7 | 8 | 0 | 0 |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |

Langkah 6 : array 6 dijumlahkan dengan array 7

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| C | 2 | 2 | 4 | 7 | 7 | 8 | 8 | 0 |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |

Langkah 7 : array 7 dijumlahkan dengan array 8

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| C | 2 | 2 | 4 | 7 | 7 | 8 | 8 | 8 |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |

Maka didapatkan array C

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| C | 2 | 2 | 4 | 7 | 7 | 8 | 8 | 8 |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |

Setelah C didapatkan, dilakukan proses penempatan sesuai dengan posisi yang didapat.

Dalam proses ini  elemen A[i] diakses, kemudian memposisikannya di posisi sebagaimana tercatat dalam C[A[i]], kemudian mengurangkan C[A[i]] dengan 1, untuk memberikan posisi setiap elemen dengan isi sama dengan A[i]. Proses ini dibutuhkan array bantu B yang ukurannya sama dengan array A, yaitu n. yang pada awalnya semua B[i] diinisialisasi dengan NIL.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| A | 3 | 6 | 4 | 1 | 3 | 4 | 1 | 4 |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| B | - | - | - | - | - | - | - | - |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| C | 2 | 2 | 4 | 7 | 7 | 8 | 8 | 8 |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |

Langkah 1 : Elemen A[8] adalah 4, dan C[4] adalah 7, maka B[7]diisi dengan 4, dan C[4] dikurangi 1

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| A | 3 | 6 | 4 | 1 | 3 | 4 | 1 | 4 |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| B | - | - | - | - | - | - | 4 | - |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| C | 2 | 2 | 4 | 7 | 7 | 8 | 8 | 8 |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |

C[4] setelah dikurangi 1

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| C | 2 | 2 | 4 | 6 | 7 | 8 | 8 | 8 |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |

Langkah 2 : Elemen A[7] adalah 1, dan C[1] adalah 2, maka B[2]diisi dengan 1, dan C[1] dikurangi 1

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| A | 3 | 6 | 4 | 1 | 3 | 4 | 1 | 4 |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| B | - | 1 | - | - | - | - | 4 | - |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| C | 2 | 2 | 4 | 6 | 7 | 8 | 8 | 8 |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |

C[1] setelah dikurangi 1

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| C | 1 | 2 | 4 | 6 | 7 | 8 | 8 | 8 |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |

Langkah 3 : Elemen A[6] adalah 4, dan C[4] adalah 6, maka B[6]diisi dengan 4, dan C[4] dikurangi 1

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| A | 3 | 6 | 4 | 1 | 3 | 4 | 1 | 4 |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| B | - | 1 | - | - | - | 4 | 4 | - |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| C | 1 | 2 | 4 | 6 | 7 | 8 | 8 | 8 |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |

C[4] setelah dikurangi 1

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| C | 1 | 2 | 4 | 5 | 7 | 8 | 8 | 8 |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |

Langkah 4 : Elemen A[5] adalah 3, dan C[3] adalah 4, maka B[4]diisi dengan 3, dan C[3] dikurangi 1

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| A | 3 | 6 | 4 | 1 | 3 | 4 | 1 | 4 |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| B | - | 1 | - | 3 | - | 4 | 4 | - |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| C | 1 | 2 | 4 | 5 | 7 | 8 | 8 | 8 |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |

C[3] setelah dikurangi 1

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| C | 1 | 2 | 3 | 5 | 7 | 8 | 8 | 8 |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |

Langkah 5 : Elemen A[4] adalah 1, dan C[1] adalah 1, maka B[1]diisi dengan 1, dan C[1] dikurangi 1

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| A | 3 | 6 | 4 | 1 | 3 | 4 | 1 | 4 |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| B | 1 | 1 | - | 3 | - | 4 | 4 | - |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| C | 1 | 2 | 3 | 5 | 7 | 8 | 8 | 8 |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |

C[1] setelah dikurangi 1

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| C | 0 | 2 | 3 | 5 | 7 | 8 | 8 | 8 |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |

Langkah 6 : Elemen A[3] adalah 4, dan C[4] adalah 5, maka B[5]diisi dengan 4, dan C[4] dikurangi 1

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| A | 3 | 6 | 4 | 1 | 3 | 4 | 1 | 4 |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| B | 1 | 1 | - | 3 | 4 | 4 | 4 | - |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| C | 0 | 2 | 3 | 5 | 7 | 8 | 8 | 8 |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |

C[4] setelah dikurangi 1

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| C | 0 | 2 | 3 | 4 | 7 | 8 | 8 | 8 |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |

Langkah 7 : Elemen A[2] adalah 6, dan C[6] adalah 8, maka B[8]diisi dengan 6, dan C[6] dikurangi 1

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| A | 3 | 6 | 4 | 1 | 3 | 4 | 1 | 4 |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| B | 1 | 1 | - | 3 | 4 | 4 | 4 | 6 |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| C | 1 | 2 | 3 | 5 | 7 | 8 | 8 | 8 |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |

C[6] setelah dikurangi 1

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| C | 0 | 2 | 3 | 4 | 7 | 7 | 8 | 8 |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |

Langkah 8 : Elemen A[1] adalah 3, dan C[3] adalah 3, maka B[3]diisi dengan 3, dan C[3] dikurangi 1

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| A | 3 | 6 | 4 | 1 | 3 | 4 | 1 | 4 |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| B | 1 | 1 | 3 | 3 | 4 | 4 | 4 | 6 |

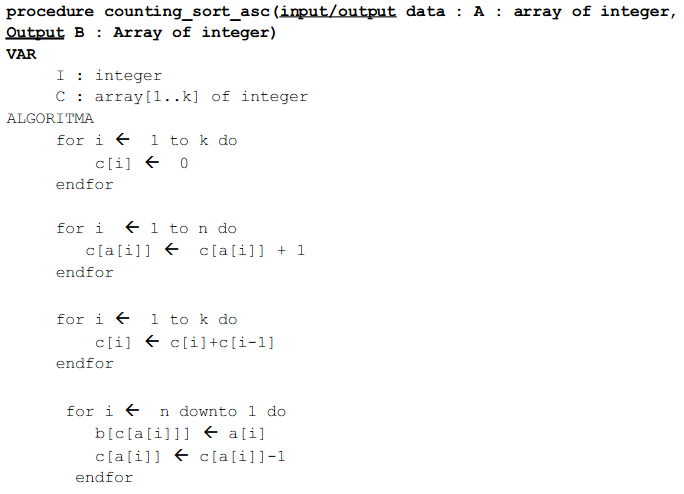
|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| C | 1 | 2 | 3 | 5 | 7 | 8 | 8 | 8 |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |

C[3] setelah dikurangi 1

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| C | 0 | 2 | 2 | 4 | 7 | 7 | 8 | 8 |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |

1. **Kompleksitas Algoritma**

**Algoritma**



1. Kompleksitas waktu
2. Operasi pengisian nilai

* c[i] 🡨 0 n kali
* c[a[i]] 🡨 c[a[i]] + 1 n kali
* c[i] 🡨 c[i] + c[i-1] n-1 kali
* b[c[a[i]]] 🡨 a[i] n kali
* c[a[i]] 🡨 c[a[i]]-1 n kali

T(n) = n + n + (n-1) + n + n = 5n - 1

1. Operasi penjumlahan

* c[a[i]] 🡨 c[a[i]] + 1 n kali
* c[i] 🡨 c[i] + c[i-1] n-1 kali

T(n) = n + (n-1) = 2n -1

1. Operasi pengurangan

* C[a[i]] 🡨 c[a[i]] – 1 n kali

T(n) = n

**Total** T(n) = 5n -1 + 2n -1 + n = 8n - 2

1. Kompleksitas waktu asimptotik

for i 🡨 1 to k do

c[i] 🡨 0 O(1)

endfor

for i 🡨 1 to n do

c[a[i]] 🡨 c[a[i]] + 1 O(1)

endfor

for i 🡨 1 to k do

c[i] 🡨 c[i] + c[i-1] O(1)

endfor

for i 🡨 n downto i do

b[c[a[i]] 🡨 a[i] O(1)

c[a[i]] 🡨 c[a[i]] - 1

endfor

**Sehingga,**

Big-O (f(n)) = n . O(1) + n . O(1) + (n-1) . O(1) + n . (O(1) + O(1))

= O(n) + O(n) + O(n-1) + n . O(1)

= O(n) + O(n)

= O(n)

1. **Code Program**

#include<iostream>

#include <chrono>

using namespace std;

using namespace std::chrono;

int k=0;

/\*Method to sort the array\*/

void Counting\_Sort(int A[],int B[],int n)

{

int C[k];

for(int i=0;i<k+1;i++)

{

/\*It will initialize the C with zero\*/

C[i]=0;

}

for(int j=1;j<=n;j++)

{

/\*It will count the occurence of every element x in A

and increment it at position x in C\*/

C[A[j]]++;

}

for(int i=1;i<=k;i++)

{

/\*It will store the last

occurence of the element i \*/

C[i]+=C[i-1];

}

for(int j=n;j>=1;j--)

{

/\*It will place the elements at their

respective index\*/

B[C[A[j]]]=A[j];

/\*It will help if an element occurs

more than one time\*/

C[A[j]]=C[A[j]]-1;

}

}

int main()

{

int n;

cout<<"Enter the size of the array :";

cin>>n;

/\*A stores the elements input by user \*/

/\*B stores the sorted sequence of elements\*/

int A[n],B[n];

for(int i=1;i<=n;i++)

{

cin>>A[i];

if(A[i]>k)

{

/\*It will modify k if an element

occurs whose value is greater than k\*/

k=A[i];

}

}

auto start = high\_resolution\_clock::now();

Counting\_Sort(A,B,n);

auto stop = high\_resolution\_clock::now();

auto duration = duration\_cast<nanoseconds>(stop - start);

cout << "Time taken by function: "

<< duration.count() << " nanoseconds" << endl;

/\*It will print the sorted sequence on the

console\*/

for(int i=1;i<=n;i++)

{

cout<<B[i]<<" ";

}

cout<<endl;

return 0;

}

Output :

