TA: Jade Cheng ICS 311 Quiz Solution #3 Feb 11, 2008

Quiz #3

What is the <u>time</u> complexity of Counting Sort? Justify Average, Best, and Worst cases. [2 pts]

Answer:

Counting Sort is a $\theta(n)$ algorithm, independent of the order of elements. The average, best and worst cases all run at $\theta(n)$.

The pass through to populate array B with 0s takes $\Theta(k)$. The pass through to count the elements that are equal to corresponding indexes in array B takes $\Theta(n)$. The pass through to sum up the number of elements that are smaller than or equal to corresponding indexes in array B takes $\Theta(k)$. Finally, the pass through the populate array C with elements from array A takes $\Theta(n)$. Therefore, the overall time is $\Theta(n + k)$. In practice, we usually use Counting Sort when we have k = O(n), in which case the run time is $\Theta(n)$.

What is the <u>space</u> complexity of Counting Sort? Justify your answer. [2 pts]

Answer:

The space complexity of Counting Sort is $\Theta(V_{max} - V_{min} + 1) + \Theta(n)$.

Counting Sort requires two additional arrays. Array B[0...K] provides temporary working space. Array C[0...n] holds the sorted output. Array B takes a space of $\Theta(k)$, which equals to $\Theta(V_{max} - V_{min} + 1)$. Array C takes a space of $\Theta(n)$. Therefore the overall space complexity of Counting Sort is $\Theta(V_{max} - V_{min} + 1) + \Theta(n)$.

Perform Counting Sort on the following array. Show all steps and data structures. [4 pts]

$A = < 5 \ 9 \ 11 \ 9 \ 5 \ 1 \ 10 \ 15 >$

Answer:

1	2 0	3 0	4 0	5	6	7	8	9	10	11	12	13	14	1
0	0	0	0				_							
				U	0	0	0	0	0	0	0	0	0	0
					Г	1								
Array B														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	1
1	0	0	0	2	0	0	0	2	1	1	0	0	0	1
					Г	1								
Array B														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	1:
1	1	1	1	3	3	3	3	5	6	7	7	7	7	8
					Г	1								
					<∕	7								
1	2	3	4	5	6	7	9	9	10	11	12	13	14	1
1	1	1	1	3	3	3	3	5	6	7	7	7	7	7
	_													-
1	2	3	4	5	6	7	8							
x	x	x	x	x	X	x	15							
				_		L								
					$\overline{}$	/								
1	2	3	4	5	6	7	8	9	10	11	12	13	14]
1	1	1	1	3	3	3	3	5	5	7	7	7	7	
1	2	3	4	5	6	7	8							
x	X	X	х	x	10	х	15							
						L								
					\geq									
1	2	3	4	5	6	7	8	9	10	11	12	13	14	
0	1	1	1	3	3	3	3	5	5	7	7	7	7	J
1	2	3	4	5	6	7	8							
1	X	X	x	x	10	X	15							
	1 1 1 1 1 1 x 1 1 1 x 1 1 0 1 1	1 2 1 1 1 2 1 2 1 2 X X 1 2 X X 1 2 X X 1 2 X X 1 2 X X 1 2 X X 1 2 1 2 1 2 1 2 1 2 1 2 1 2 1 2 1 2 1 2 1 2 1 2 1 X	1 2 3 1 1 1 1 2 3	1 2 3 4 1 1 1 1 1 2 3 4 1 1 1 1 1 2 3 4 1 1 1 1 1 2 3 4 X X X X 1 2 3 4 1 1 1 1 1 2 3 4 X X X X 1 2 3 4 X X X X 1 2 3 4 X X X X 1 2 3 4 0 1 1 1 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4	1 2 3 4 5 1 1 1 1 3 1 2 3 4 5 1 1 1 1 3 1 2 3 4 5 1 1 1 1 3 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 1 1 1 3 1 2 3 4 5 1 1 1 1 3 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 0 1 1 1 3 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 <td>$\begin{array}{c ccccccccccccccccccccccccccccccccccc$</td> <td>$\begin{array}{c ccccccccccccccccccccccccccccccccccc$</td>	$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$							

Array B	_						_		_	_		_		_
Index	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Contents	0	1	1	1	2	3	3	3	5	5	7	7	7	7
Array C											•			
Index	1	2	3	4	5	6	7	8						
Contents	1	x	5	x	x	10	x	15						
Array B			<u> </u>	<u> </u>	1 _		-							
Index	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Contents	0	1	1	1	2	3	3	3	4	5	7	7	7	7
Array C	—	1	1	1	r –									
Index	1	2	3	4	5	6	7	8						
Contents	1	x	5	x	9	10	x	15						
Array B														
Index	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Contents	0	1	1	1	2	3	3	3	4	5	6	7	7	7
Array C														
Index	1	2	3	4	5	6	7	8						
Contents	1	x	5	x	9	10	11	15						
Index	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Contents	0	1	1	1	2	3	3	3	3	5	6	7	7	7
Array C		1			1						1			
Index	1	2	3	4	5	6	7	8						
Contents	1	x	5	9	9	10	11	15						
Array B						\sim								
Index	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Contents	0	1	1	1	1	3	3	3	3	5	6	7	7	7
Array C														
Index	1	2	3	4	5	6	7	8						
Contents	1	5	5	9	9	10	11	15						
	_		_	_	_	_	_							

Perform Radix Sort on the following numbers. Show all steps. [4 pts]

941 227 321 199 227

Answer:



200