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230701397

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Name :S.M.Miruthyunjai

Divide and Conquer

4.a. Number of Zeros in a Given Array

Aim: Given an array of 1s and 0s this has all 1s first followed by all 0s. Aim is to find the number of 0s. Write a program using Divide and Conquer to Count the number of zeroes in the given array.

Input Format

First Line Contains Integer m – Size of array

Next m lines Contains m numbers – Elements of an array

Output Format

First Line Contains Integer – Number of zeroes present in the given array.

Algorithm:

```
function count(a, left, right) {
```

```
    // base case: if left index exceeds right index
```

```
    if left is greater than right {
```

```
        return 0
```

```
    }
```

```
    initialize mid as (left + right) / 2 // find the middle index
```

```
    // check if the middle element is 1
```

```
    if a[mid] is equal to 1 {
```

```
        // check if the next element is 0
```

```
        if a[mid + 1] is equal to 0 {
```

```
            // count zeros from mid + 1 to right
```

```

        initialize c as (right - (mid + 1)) + 1
        return c
    } else {
        // search in the right half
        return count(a, mid + 1, right)
    }
}

// check if both ends are 0
else if a[left] is equal to 0 and a[right] is equal to 0 {
    return right + 1 // return total count of elements
}

// search in the left half
else {
    return count(a, left, mid - 1)
}
}

function main() {
    initialize n // number of elements
    read n from user

    initialize arr array of size n // array to hold binary values

    // read values into the arr array
    for i from 0 to n - 1 {
        read arr[i] from user
    }
}

```

initialize left as 0 // left index

initialize right as n - 1 // ri

Program:

```
#include <stdio.h>
```

```
int count(int a[],int left,int right)
```

```
{
```

```
    if(left>right)
```

```
    {
```

```
        return 0;
```

```
    }
```

```
    int mid=(left+right)/2;
```

```
    if(a[mid]==1)
```

```
    {
```

```
        if(a[mid+1]==0)
```

```
        {
```

```
            int c= (right-(mid+1))+1;
```

```
            return c;
```

```
        }
```

```
    else{
```

```
        return count(a,mid+1,right);
```

```
    }
```

```
}
```

```
else if(a[left]==0 && a[right]==0)
```

```
{
```

```
    return right+1;
```

```
}
```

```
else
```

```
{  
    return count(a,left,mid-1);  
}  
  
}  
  
int main()  
{  
    int n;  
    scanf("%d",&n);  
    int arr[n];  
    for(int i=0;i<n;i++){  
        scanf("%d",&arr[i]);  
    }  
    int left=0;  
    int right=n-1;  
    int result=count(arr,left,right);  
    printf("%d",result);  
}
```

Output:

	Input	Expected	Got	
✓	5 1 1 1 0 0	2	2	✓
✓	10 1 1 1 1 1 1 1 1 1 1 1	0	0	✓
✓	8 0 0 0 0 0 0 0 0 0	8	8	✓

4.b. Majority Element

Aim: Given an array `nums` of size `n`, return *the majority element*.

The majority element is the element that appears more than $\lfloor n / 2 \rfloor$ times. You may assume that the majority element always exists in the array.

Example 1:

Input: `nums = [3,2,3]`

Output: 3

Example 2:

Input: `nums = [2,2,1,1,1,2,2]`

Output: 2

Constraints:

```
n == nums.length 1 <= n
<= 5 * 104 -2 <= nums[i]
<= 231 - 1
```

Algorithm:

```
int divide(a, l, r, n) {
```

```
    // base case: if left index equals right index
```

```
    if l is equal to r {
```

```
        return a[l] // return the only element
```

```
    }
```

```
    initialize mid as (l + r) / 2 // find the middle index
```

```
    // recursively divide the array
```

```
    initialize min as divide(a, l, mid, n) // find min in left half
```

```
    initialize max as divide(a, mid + 1, r, n) // find max in right half
```

```
    initialize leftc as 0 // counter for min occurrences
```

```
    initialize rightc as 0 // counter for max occurrences
```

```

// count occurrences of min and max in the entire array
for i from 0 to n - 1 {
    if a[i] is equal to min {
        increment leftc by 1 // count occurrences of min
    } else {
        increment rightc by 1 // count occurrences of max
    }
}

// check if min occurs more than n/2 times
if leftc is greater than (n / 2) {
    return min // return min if it is the majority element
} else {
    return max // return max otherwise
}

}

int main() {
    initialize n // number of elements
    read n from user

    initialize a array of size n // array to hold input values

    // read values into the array
    for j from 0 to n - 1 {
        read a[j] from user
    }
}

```

```

initialize l as 0 // left index

initialize r as n - 1 // right index


// call the divide function

initialize result as divide(a, l, r, n)


print result // output the final majority element
}

```

Program:

```

#include<stdio.h>

int divide(int a[],int l,int r,int n){

    if(l==r)

    {

        return a[l];

    }

    int mid=(l+r)/2;

    int min=divide(a,l,mid,n);

    int max=divide(a,mid+1,r,n);

    int leftc=0,rightc=0;

    for(int i=0;i<n;i++)

    {

        if(a[i]==min)

        {

            leftc++;

        }

        else

```



```

        {
            rightc++;
        }
    }
    if(leftc>(n/2))
    {
        return min;

    }
    else
    {
        return max;
    }
}

int main(){
    int n;

    scanf("%d",&n);
    int a[n];
    for(int j=0;j<n;j++){

        scanf("%d",&a[j]);
    }

    int l=0,r=n-1;
    int result=divide(a,l,r,n);
    printf("%d",result);
}

```

Output:

	Input	Expected	Got	
✓	3 3 2 3	3	3	✓

4.c. Finding Floor Value

Aim: Given a sorted array and a value x, the floor of x is the largest element in array smaller than or equal to x. Write divide and conquer algorithm to find floor of x.

Input Format

First Line Contains Integer n – Size of array

Next n lines Contains n numbers – Elements of an array

Last Line Contains Integer x – Value for x

Output Format

First Line Contains Integer – Floor value for x

Algorithm:

```
int large(arr, l, r, x){  
    // Base case: if the range is invalid  
    if r < l  
        return 0 // return 0 when there is no valid element  
  
    // Calculate the middle index  
    mid = (l + r) / 2  
  
    // Check if the middle element is equal to x  
    if arr[mid] is equal to x  
        return mid // return the index of x if found  
  
    // If the middle element is less than x  
    else if arr[mid] < x  
        // Recursively search in the right half  
        floorIndex = large(arr, mid + 1, r, x)  
  
    // Check if a valid floor index is found  
    if floorIndex is not equal to 0
```

```

        return floorIndex // return the found index
    else
        return mid // return mid as the largest element less than x

// If the middle element is greater than x, search in the left half
else
    return large(arr, l, mid - 1, x) // search in the left half
}

Int main()

    initialize n // number of elements in the array
    read n from user

    initialize arr of size n // array to hold input values

    // Read values into the array
    for i from 0 to n - 1
        read arr[i] from user

    initialize l as 0 // left index
    initialize r as n - 1 // right index

    initialize x // the value for which we want to find the largest element less than or equal to
x
    read x from user

    // Call the large function
    result = large(arr, l, r, x)

```

```
// Check the result  
if result is equal to 0  
    print x // if no valid element, print x  
else  
    print arr[result] // print the largest element less than or equal to x
```

Program:

```
#include<stdio.h>  
  
int large(int arr[],int l,int r,int x){  
    if (r < l) {  
        return 0;  
    }  
    int mid=(l+r)/2;  
    if (arr[mid]==x)  
    {  
        return mid;  
    }  
    else if (arr[mid]<x)  
    {  
        int floorIndex=large(arr,mid+1,r,x);  
        if(floorIndex!=0)  
        {  
            return floorIndex;  
        }  
    }  
    else  
    {  
        return floorIndex=mid;  
    }  
}
```

```
    }  
    else  
    {  
        return large(arr,l,mid-1,x);  
    }  
}
```

```
int main(){  
    int n;  
    scanf("%d",&n);  
    int arr[n];  
    for (int i=0;i<n;i++){  
        scanf("%d",&arr[i]);  
    }  
    int l=0;  
    int r=n-1;  
    int x;  
    scanf("%d",&x);  
    int result=large(arr,l,r,x);  
    if (result == 0)  
    {  
        printf ("%d",x);  
    }  
    else  
    {  
        printf ("%d",arr[result]);  
    }  
}
```

}

Output:

	Input	Expected	Got	
✓	6 1 2 8 10 12 19 5	2	2	✓
✓	5 10 22 85 108 129 100	85	85	✓
✓	7 3 5 7 9 11 13 15 10	9	9	✓

4.d. Two Elements Sum to X

Aim: Given a sorted array of integers say arr[] and a number x. Write a recursive program using divide and conquer strategy to check if there exist two elements in the array whose sum = x. If there exist such two elements then return the numbers, otherwise print as “No”.

Note: Write a Divide and Conquer Solution

Input Format

First Line Contains Integer n – Size of array

Next n lines Contains n numbers – Elements of an array

Last Line Contains Integer x – Sum Value

Output Format

First Line Contains Integer – Element1

Second Line Contains Integer – Element2 (Element 1 and Elements 2 together sums to value “x”)

Algorithm:

```
int findPairWithSum(arr, left, right, x){
```

```
    // Base case: if there are no more pairs to check
```

```
    if left >= right
```

```
        print "No" // No pair found
```

```
        return
```

```
    // Calculate the sum of the elements at the left and right indices
```

```
    sum = arr[left] + arr[right]
```

```
    // Check if the sum is equal to x
```

```
    if sum is equal to x
```

```
        print arr[left] // Print the first element of the pair
```

```
        print arr[right] // Print the second element of the pair
```

```
        return
```

```
    // If the sum is less than x, move the left index up
```

```
    if sum < x
```

```

        findPairWithSum(arr, left + 1, right, x) // Recursive call with increased left index
    else
        findPairWithSum(arr, left, right - 1, x) // Recursive call with decreased right index
}

function main()
    initialize n // number of elements in the array
    read n from user

    initialize arr of size n // array to hold input values

    // Read values into the array
    for i from 0 to n - 1
        read arr[i] from user

    initialize x // the target sum value
    read x from user

    // Call the findPairWithSum function
    findPairWithSum(arr, 0, n - 1, x)

```

Program:

```

#include <stdio.h>

void findPairWithSum(int arr[], int left, int right, int x) {
    if (left >= right) {
        //No pair found
        printf("No\n");
    }
}

```

```

        return;
    }

    int sum = arr[left] + arr[right];

    if (sum == x){
        // If the pair is found
        printf("%d\n%d\n", arr[left], arr[right]);
        return;
    }

    if (sum < x){

        findPairWithSum(arr, left + 1, right, x);
    }
    else{

        findPairWithSum(arr, left, right - 1, x);
    }
}

int main() {
    int n;
    scanf("%d", &n);
    int arr[n];
    for (int i = 0; i < n; i++) {
        scanf("%d", &arr[i]);
    }
    int x;

```

```
scanf("%d", &x);

    findPairWithSum(arr, 0, n - 1, x);
}
```

Output:

	Input	Expected	Got	
✓	4	4	4	✓
	2	10	10	
	4			
	8			
	10			
	14			
✓	5	No	No	✓
	2			
	4			
	6			
	8			
	10			
	100			

4.e. Implementation of Quick Sort

Aim: Write a Program to Implement the Quick Sort Algorithm

Input Format:

The first line contains the no of elements in the list-n

The next n lines contain the elements.

Output:

Sorted list of elements

Algorithm:

```
int partition(a, left, right)
{
    pivot = right // Choose the last element as pivot
    i = left - 1 // Index of smaller element

    for j from left to right - 1
    {
        if a[j] < a[pivot]
        {
            i++
            // Swap a[i] and a[j]
            temp = a[i]
            a[i] = a[j]
            a[j] = temp
        }
    }

    // Swap a[i + 1] and a[right]
    temp = a[i + 1]
    a[i + 1] = a[right]
```

```
a[right] = temp
    return (i + 1) // Return the partition index
}
```

```
function quick(a, left, right)
{
    if left < right
    {
        p = partition(a, left, right) // Partition the array
        quick(a, left, p - 1)        // Recursively sort the left sub-array
        quick(a, p + 1, right)       // Recursively sort the right sub-array
    }
}
```

```
int main()
{
    initialize n // number of elements
    read n from user

    initialize a of size n // array to hold input values
    for i from 0 to n - 1
    {
        read a[i] from user
    }

    quick(a, 0, n - 1) // Call the quicksort function

    // Print the sorted array
```

```
for i from 0 to n - 1
{
    print a[i]
}
}
```

Program:

```
#include <stdio.h>
```

```
int partition(int a[], int left, int right) {
```

```
    int pivot = right;
```

```
    int i = left-1;
```

```
    for (int j = left; j < right; j++) {
```

```
        if (a[j] < a[pivot]) {
```

```
            i++;
```

```
            int temp = a[i];
```

```
            a[i] = a[j];
```

```
            a[j] = temp;
```

```
        }
```

```
    }
```

```
    int temp = a[i + 1];
```

```
    a[i + 1] = a[right];
```

```
    a[right] = temp;
```

```
    return (i + 1);
```