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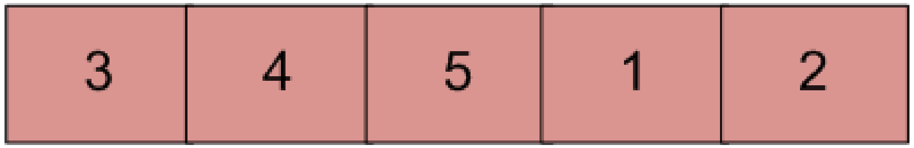
Search an element in a sorted and pivoted array

Question:
An element in a sorted array can be found in O(log n) time via binary search. But suppose I rotate the sorted array at some pivot unknown to you beforehand. So for instance, 1 2 3 4 5 might become 3 4 5 1 2. Devise a way to find an element in the rotated array in O(log n) time.



3	4	5	1	2

Solution:
Thanks to Ajay Mishra for initial solution.

Algorithm:
Find the pivot point, divide the array in two sub-arrays and call binary search.
The main idea for finding pivot is – for a sorted (in increasing order) and pivoted array, pivot element is the only only element for which next element to it is smaller than it.
Using above criteria and binary search methodology we can get pivot element in O(logn) time

```
Input arr[] = {3, 4, 5, 1, 2}
Element to Search = 1
  1) Find out pivot point and divide the array in two
      sub-arrays. (pivot = 2) /*Index of 5*/
```

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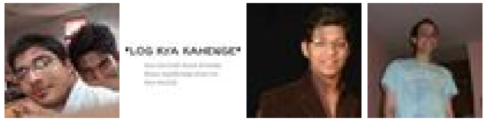

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```
  2) Now call binary search for one of the two sub-arrays.
      (a) If element is greater than 0th element then
             search in left array
      (b) Else Search in right array
          (1 will go in else as 1 < 0th element(3))
  3) If element is found in selected sub-array then return index
     Else return -1.
```

Implementation:

```
/* Program to search an element in a sorted and pivoted array*/
#include <stdio.h>

int findPivot(int[], int, int);
int binarySearch(int[], int, int, int);

/* Searches an element no in a pivoted sorted array arrp[]
   of size arr_size */
int pivotedBinarySearch(int arr[], int arr_size, int no)
{
   int pivot = findPivot(arr, 0, arr_size-1);

   // If we didn't find a pivot, then array is not rotated at all
   if (pivot == -1)
     return binarySearch(arr, 0, arr_size-1, no);

   // If we found a pivot, then first compare with pivot and then
   // search in two subarrays around pivot
   if (arr[pivot] == no)
     return pivot;
   if (arr[0] <= no)
     return binarySearch(arr, 0, pivot-1, no);
   else
     return binarySearch(arr, pivot+1, arr_size-1, no);
}

/* Function to get pivot. For array 3, 4, 5, 6, 1, 2 it will
   return 3. If array is not rotated at all, then it returns -1 */
int findPivot(int arr[], int low, int high)
{
   // base cases
   if (high < low)  return -1;
   if (high == low) return low;

   int mid = (low + high)/2;   /*low + (high - low)/2;*/
```

Geometric Algorithms

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```
   int mid = (low + high)/2;   /*low + (high - low)/2;*/
   if (mid < high && arr[mid] > arr[mid + 1])
     return mid;
   if (mid > low && arr[mid] < arr[mid - 1])
     return (mid-1);
   if (arr[low] >= arr[mid])
     return findPivot(arr, low, mid-1);
   else
     return findPivot(arr, mid + 1, high);
}

/* Standard Binary Search function*/
int binarySearch(int arr[], int low, int high, int no)
{
   if (high < low)
       return -1;
   int mid = (low + high)/2;  /*low + (high - low)/2;*/
   if (no == arr[mid])
     return mid;
   if (no > arr[mid])
     return binarySearch(arr, (mid + 1), high, no);
   else
     return binarySearch(arr, low, (mid -1), no);
}


/* Driver program to check above functions */
int main()
{
   // Let us search 3 in below array
   int arr1[] = {5, 6, 7, 8, 9, 10, 1, 2, 3};
   int arr_size = sizeof(arr1)/sizeof(arr1[0]);
   int no = 3;
   printf("Index of the element is %d\n",  pivotedBinarySearch(arr1, a

    // Let us search 3 in below array
   int arr2[] = {3, 4, 5, 1, 2};
   arr_size = sizeof(arr2)/sizeof(arr2[0]);
   printf("Index of the element is %d\n",  pivotedBinarySearch(arr2, a

   // Let us search for 4 in above array
   no = 4;
   printf("Index of the element is %d\n",  pivotedBinarySearch(arr2, a

   // Let us search 0 in below array
   int arr3[] = {1, 1, 1, 0, 1, 1, 1, 1, 1, 1, 1};
   no = 0;
   arr_size = sizeof(arr3)/sizeof(arr3[0]);
```

```
    printf("Index of the element is %d\n",  pivotedBinarySearch(arr3, a

    // Let us search 3 in below array
    int arr4[] = {2, 3, 0, 2, 2, 2, 2, 2, 2, 2};
    no = 3;
    arr_size = sizeof(arr4)/sizeof(arr4[0]);
    printf("Index of the element is %d\n",  pivotedBinarySearch(arr4, a

    // Let us search 2 in above array
    no = 2;
    printf("Index of the element is %d\n",  pivotedBinarySearch(arr4, a

    // Let us search 3 in below array
    int arr5[] = {1, 2, 3, 4};
    no = 3;
    arr_size = sizeof(arr5)/sizeof(arr5[0]);
    printf("Index of the element is %d\n",  pivotedBinarySearch(arr5, a

    return 0;
}
```

Output:

```
Index of the element is 8
Index of the element is 0
Index of the element is 1
Index of the element is 3
Index of the element is 1
Index of the element is 0
Index of the element is 2
```

Please note that the solution may not work for cases where the input array has duplicates.

Time Complexity O(logn)

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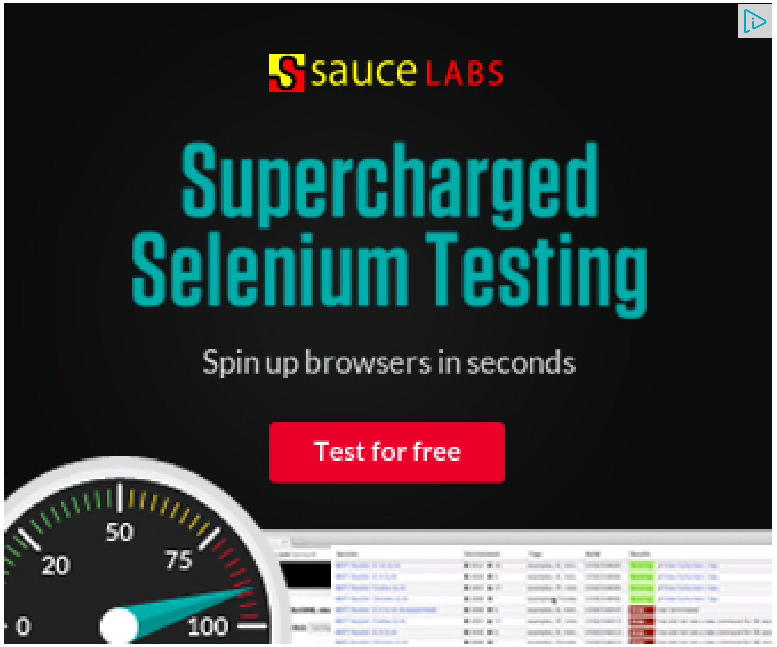

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