Window Sliding Technique

Difficulty Level : Easy • Last Updated : 10 Jul, 2021

This technique shows how a nested for loop in some problems can be converted to a single for loop to reduce the time complexity.
Let's start with a problem for illustration where we can apply this technique –

```
Given an array of integers of size 'n'.
Our aim is to calculate the maximum sum of 'k'
consecutive elements in the array.

Input  : arr[] = {100, 200, 300, 400}
         k = 2
Output : 700

Input  : arr[] = {1, 4, 2, 10, 23, 3, 1, 0, 20}
         k = 4
Output : 39
We get maximum sum by adding subarray {4, 2, 10, 23}
of size 4.

Input  : arr[] = {2, 3}
         k = 3
Output : Invalid
There is no subarray of size 3 as size of whole
array is 2.
```

So, let's analyze the problem with **Brute Force Approach**. We start with first index and sum till **k-th** element. We do it for all possible consecutive blocks or groups of k elements. This method requires nested for loop, the outer for loop starts with the

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starting element of the block of k elements and the inner or the nested loop will add up till the k-th element.

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Consider the below implementation :

C++

```
// O(n*k) solution for finding maximum sum of
// a subarray of size k
#include <bits/stdc++.h>
using namespace std;

// Returns maximum sum in a subarray of size k.
int maxSum(int arr[], int n, int k)
{
    // Initialize result
    int max_sum = INT_MIN;

    // Consider all blocks starting with i.
    for (int i = 0; i < n - k + 1; i++) {
        int current_sum = 0;
        for (int j = 0; j < k; j++)
            current_sum = current_sum + arr[i + j];

        // Update result if required.
        max_sum = max(current_sum, max_sum);
    }

    return max_sum;
}
```

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```
    int arr[] = { 1, 4, 2, 10, 2, 3, 1, 0, 20 };
    int k = 4;
    int n = sizeof(arr) / sizeof(arr[0]);
    cout << maxSum(arr, n, k);
    return 0;
}
```

Java

```
// Java code here
// O(n*k) solution for finding
// maximum sum of a subarray
// of size k
class GFG {
    // Returns maximum sum in
    // a subarray of size k.
    static int maxSum(int arr[], int n, int k)
    {
        // Initialize result
        int max_sum = Integer.MIN_VALUE;

        // Consider all blocks starting with i.
        for (int i = 0; i < n - k + 1; i++) {
            int current_sum = 0;
            for (int j = 0; j < k; j++)
                current_sum = current_sum + arr[i + j];

            // Update result if required.
            max_sum = Math.max(current_sum, max_sum);
        }

        return max_sum;
    }

    // Driver code
    public static void main(String[] args)
    {
        int arr[] = { 1, 4, 2, 10, 2, 3, 1, 0, 20 };
        int k = 4;
        int n = arr.length;
        System.out.println(maxSum(arr, n, k));
    }
}

// This code is contributed
// by  prerna saini.
```

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Python

```python
# code
import sys
print "GFG"
# O(n * k) solution for finding
# maximum sum of a subarray of size k
INT_MIN = -sys.maxsize - 1

# Returns maximum sum in a
# subarray of size k.


def maxSum(arr, n, k):

    # Initialize result
    max_sum = INT_MIN

    # Consider all blocks
    # starting with i.
    for i in range(n - k + 1):
        current_sum = 0
        for j in range(k):
            current_sum = current_sum + arr[i + j]

        # Update result if required.
        max_sum = max(current_sum, max_sum)

    return max_sum


# Driver code
arr = [1, 4, 2, 10, 2,
       3, 1, 0, 20]
k = 4
n = len(arr)
print(maxSum(arr, n, k))

# This code is contributed by mits
```

C#

```csharp
// C# code here O(n*k) solution for
// finding maximum sum of a subarray
// of size k
```

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```
    // Returns maximum sum in a
    // subarray of size k.
    static int maxSum(int[] arr, int n, int k)
    {
        // Initialize result
        int max_sum = int.MinValue;

        // Consider all blocks starting
        // with i.
        for (int i = 0; i < n - k + 1; i++) {
            int current_sum = 0;
            for (int j = 0; j < k; j++)
                current_sum = current_sum + arr[i + j];

            // Update result if required.
            max_sum = Math.Max(current_sum, max_sum);
        }

        return max_sum;
    }

    // Driver code
    public static void Main()
    {
        int[] arr = { 1, 4, 2, 10, 2, 3, 1, 0, 20 };
        int k = 4;
        int n = arr.Length;
        Console.WriteLine(maxSum(arr, n, k));
    }
}

// This code is contributed by anuj_67.
```

PHP

```
<?php
    // code
?>
<?php
// O(n*k) solution for finding maximum sum of
// a subarray of size k

// Returns maximum sum in a subarray of size k.
function maxSum($arr, $n, $k)
{
```

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Got It !

```
    // Consider all blocks
    // starting with i.
    for ( $i = 0; $i < $n - $k + 1; $i++)
    {
        $current_sum = 0;
        for ( $j = 0; $j < $k; $j++)
            $current_sum = $current_sum +
                                $arr[$i + $j];

        // Update result if required.
        $max_sum = max($current_sum, $max_sum );
    }

    return $max_sum;
}

    // Driver code
    $arr = array(1, 4, 2, 10, 2, 3, 1, 0, 20);
    $k = 4;
    $n = count($arr);
    echo maxSum($arr, $n, $k);

// This code is contributed by anuj_67.
?>
```

Javascript

```
<script>

// O(n*k) solution for finding maximum sum of
// a subarray of size k

// Returns maximum sum in a subarray of size k.
function maxSum( arr, n, k){
    // Initialize result
    let max_sum = Number.MIN_VALUE;

    // Consider all blocks starting with i.
    for (let i = 0; i < n - k + 1; i++) {
        let current_sum = 0;
        for (let j = 0; j < k; j++)
            current_sum = current_sum + arr[i + j];

        // Update result if required.
        max_sum = Math.max(current_sum, max_sum);
    }
```

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Got It !

```
}

// Driver code
let arr = [ 1, 4, 2, 10, 2, 3, 1, 0, 20 ];
let k = 4;
let n = arr.length;
document.write(maxSum(arr, n, k));

</script>
```

Output

```
24
```

It can be observed from the above code that the time complexity is **O(k*n)** as it contains two nested loops.

Window Sliding Technique

The technique can be best understood with the window pane in bus, consider a window of length **n** and the pane which is fixed in it of length **k**. Consider, initially the pane is at extreme left i.e., at 0 units from the left. Now, co-relate the window with array arr[] of size n and pane with current_sum of size k elements. Now, if we apply force on the window such that it moves a unit distance ahead. The pane will cover next **k** consecutive elements.
Consider an array **arr[]** = {5, 2, -1, 0, 3} and value of **k** = 3 and **n** = 5
Applying sliding window technique :

1. We compute the sum of first k elements out of n terms using a linear loop and store the sum in variable window_sum.
2. Then we will graze linearly over the array till it reaches the end and simultaneously keep track of maximum sum.
3. To get the current sum of block of k elements just subtract the first element from the previous block and add the last element of the current block .

The below representation will make it clear how the window slides over the array.
This is the initial phase where we have calculated the initial window sum starting from index 0 . At this stage the window sum is 6. Now, we set the maximum_sum as current window i.e 6.

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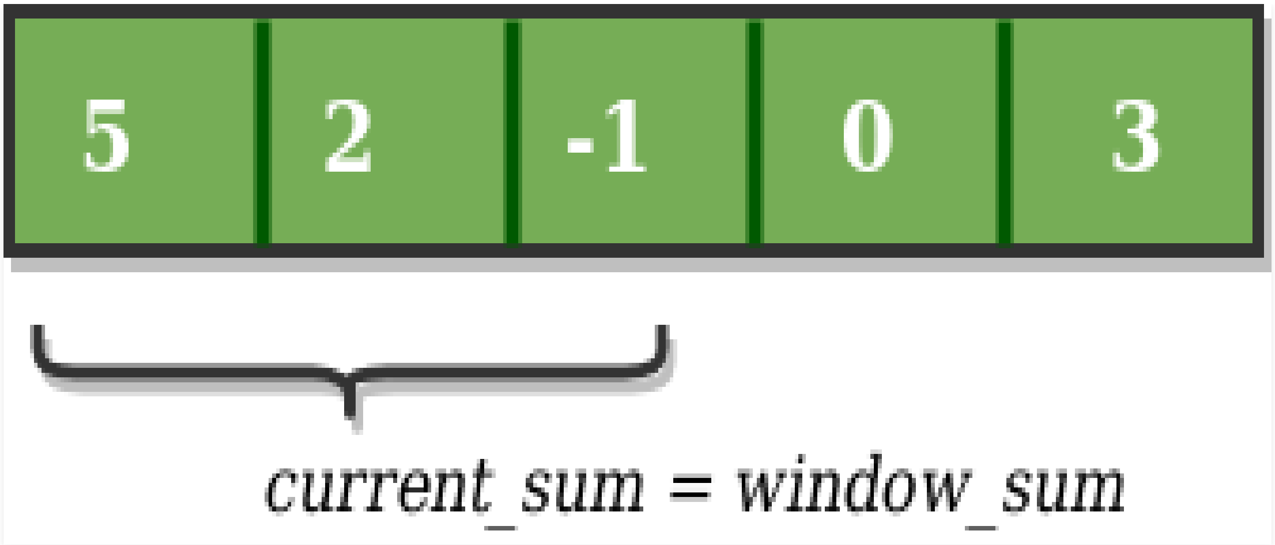
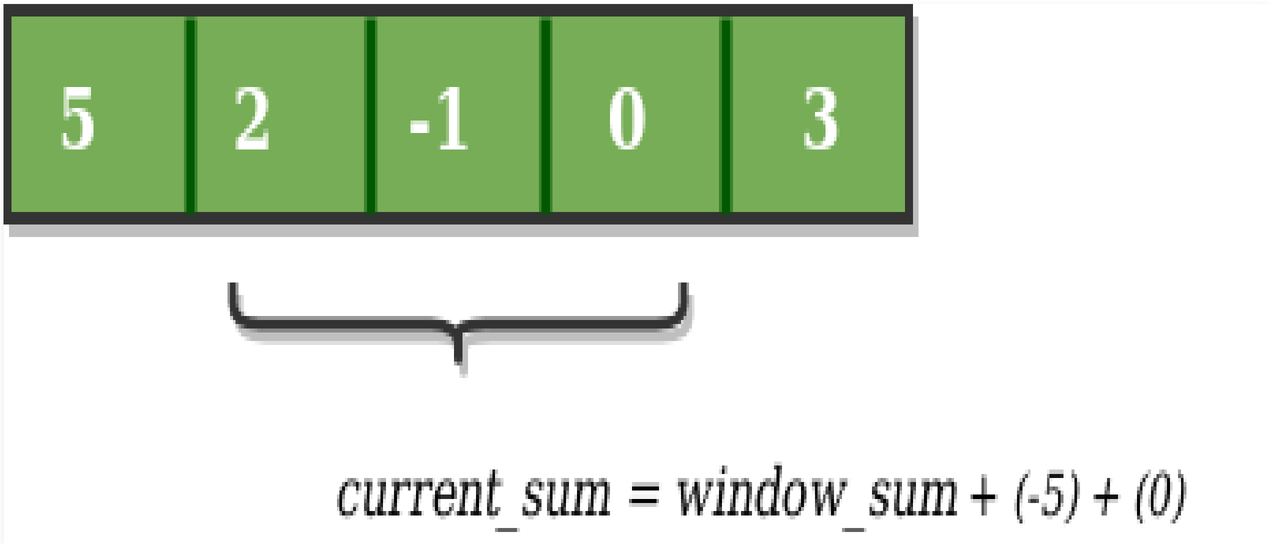


Now, we slide our window by a unit index. Therefore, now it discards 5 from the window and adds 0 to the window. Hence, we will get our new window sum by subtracting 5 and then adding 0 to it. So, our window sum now becomes 1. Now, we will compare this window sum with the maximum_sum. As it is smaller we wont the change the maximum_sum.



Similarly, now once again we slide our window by a unit index and obtain the new window sum to be 2. Again we check if this current window sum is greater than the maximum_sum till now. Once, again it is smaller so we don't change the maximum_sum.

Therefore, for the above array our maximum_sum is 6.

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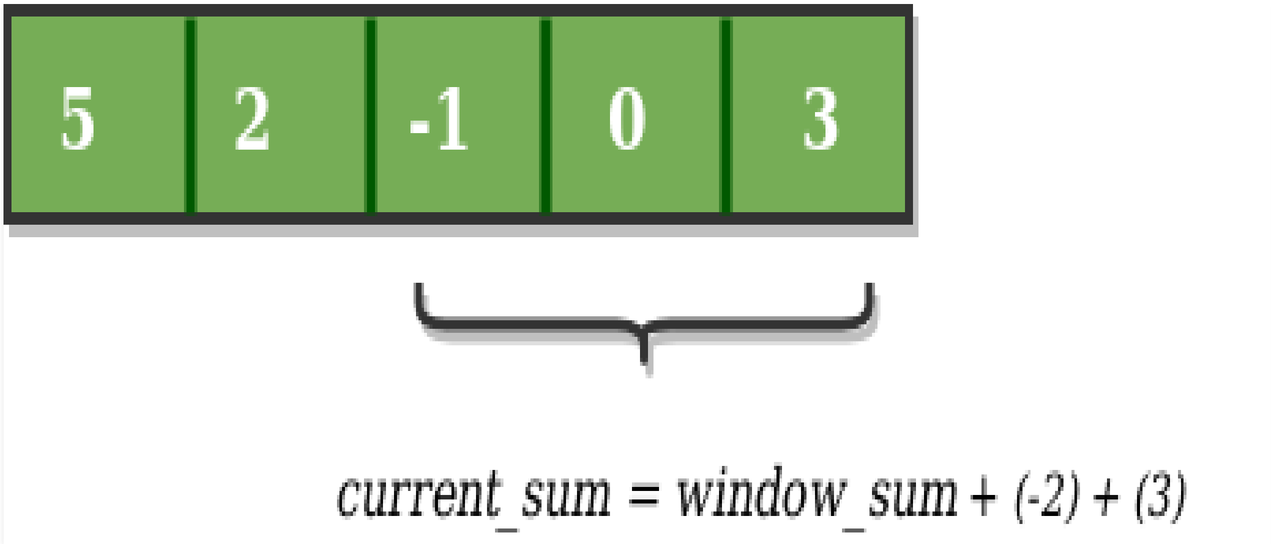

code for the above description :

C++

```
// O(n) solution for finding maximum sum of
// a subarray of size k
#include <iostream>
using namespace std;

// Returns maximum sum in a subarray of size k.
int maxSum(int arr[], int n, int k)
{
    // n must be greater
    if (n < k) {
        cout << "Invalid";
        return -1;
    }

    // Compute sum of first window of size k
    int max_sum = 0;
    for (int i = 0; i < k; i++)
        max_sum += arr[i];

    // Compute sums of remaining windows by
    // removing first element of previous
    // window and adding last element of
    // current window.
    int window_sum = max_sum;
    for (int i = k; i < n; i++) {
        window_sum += arr[i] - arr[i - k];
        max_sum = max(max_sum, window_sum);
    }
```

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Got It !

```
}

// Driver code
int main()
{
    int arr[] = { 1, 4, 2, 10, 2, 3, 1, 0, 20 };
    int k = 4;
    int n = sizeof(arr) / sizeof(arr[0]);
    cout << maxSum(arr, n, k);
    return 0;
}
```

Java

```
// Java code for
// O(n) solution for finding
// maximum sum of a subarray
// of size k
class GFG {

    // Returns maximum sum in
    // a subarray of size k.
    static int maxSum(int arr[], int n, int k)
    {
        // n must be greater
        if (n < k) {
            System.out.println("Invalid");
            return -1;
        }

        // Compute sum of first window of size k
        int max_sum = 0;
        for (int i = 0; i < k; i++)
            max_sum += arr[i];

        // Compute sums of remaining windows by
        // removing first element of previous
        // window and adding last element of
        // current window.
        int window_sum = max_sum;
        for (int i = k; i < n; i++) {
            window_sum += arr[i] - arr[i - k];
            max_sum = Math.max(max_sum, window_sum);
        }

        return max_sum;
    }
```

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Got It !

```
    public static void main(String[] args)
    {
        int arr[] = { 1, 4, 2, 10, 2, 3, 1, 0, 20 };
        int k = 4;
        int n = arr.length;
        System.out.println(maxSum(arr, n, k));
    }
}

// This code is contributed
// by  prerna saini.
```

Python

```
# O(n) solution for finding
# maximum sum of a subarray of size k


def maxSum(arr, k):
    # length of the array
    n = len(arr)

    # n must be greater than k
    if n < k:
        print("Invalid")
        return -1

    # Compute sum of first window of size k
    window_sum = sum(arr[:k])

    # first sum available
    max_sum = window_sum

    # Compute the sums of remaining windows by
    # removing first element of previous
    # window and adding last element of
    # the current window.
    for i in range(n - k):
        window_sum = window_sum - arr[i] + arr[i + k]
        max_sum = max(window_sum, max_sum)

    return max_sum


# Driver code
arr = [1, 4, 2, 10, 2, 3, 1, 0, 20]
k = 4
```

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Got It !

```
# This code is contributed by Kyle McClay
```

C#

```
// C# code for O(n) solution for finding
// maximum sum of a subarray of size k
using System;

class GFG {

    // Returns maximum sum in
    // a subarray of size k.
    static int maxSum(int[] arr, int n, int k)
    {

        // n must be greater
        if (n < k) {
            Console.WriteLine("Invalid");
            return -1;
        }

        // Compute sum of first window of size k
        int max_sum = 0;
        for (int i = 0; i < k; i++)
            max_sum += arr[i];

        // Compute sums of remaining windows by
        // removing first element of previous
        // window and adding last element of
        // current window.
        int window_sum = max_sum;
        for (int i = k; i < n; i++) {
            window_sum += arr[i] - arr[i - k];
            max_sum = Math.Max(max_sum, window_sum);
        }

        return max_sum;
    }

    // Driver code
    public static void Main()
    {
        int[] arr = { 1, 4, 2, 10, 2, 3, 1, 0, 20 };
        int k = 4;
        int n = arr.Length;
        Console.WriteLine(maxSum(arr, n, k));
    }
```

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Got It !

```
// This code is contributed by anuj_67.
```

PHP

```php
<?php
// O(n) solution for finding maximum sum of
// a subarray of size k

// Returns maximum sum in a
// subarray of size k.
function maxSum( $arr, $n, $k)
{
    // n must be greater
    if ($n < $k)
    {
        echo "Invalid";
        return -1;
    }

    // Compute sum of first
    // window of size k
    $max_sum = 0;
    for($i = 0; $i < $k; $i++)
    $max_sum += $arr[$i];

    // Compute sums of remaining windows by
    // removing first element of previous
    // window and adding last element of
    // current window.
    $window_sum = $max_sum;
    for ($i = $k; $i < $n; $i++)
    {
        $window_sum += $arr[$i] - $arr[$i - $k];
        $max_sum = max($max_sum, $window_sum);
    }

    return $max_sum;
}

    // Driver code
    $arr = array(1, 4, 2, 10, 2, 3, 1, 0, 20);
    $k = 4;
    $n = count($arr);
    echo maxSum($arr, $n, $k);

// This code is contributed by anuj_67
?>
```

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Javascript

```javascript
// Javascript code for
// O(n) solution for finding
// maximum sum of a subarray
// of size k
function maxSumofK(arr, k) {
let max = 0;
let sum = 0;
//find initial sum of first k elements
for(let n = 0; n <  k ; n++) {
    sum +=  arr[n];
}
//iterate the array once and increment the right edge
 for(let i = k; i < arr.length; i++) {
        sum += arr[i] - arr[i-k];
        //compare if sum is more than max, if yes then replace max with new sum
           if(sum > max) {
               max = sum;
           }
        }
    return max;
}

let arr = [1, 4, 2, 10, 2, 3, 1, 0, 20 ];
console.log(maxSumofK(arr, 4))
//output 28
```

Output

```
24
```

Now, it is quite obvious that the Time Complexity is linear as we can see that only one loop runs in our code. Hence, our Time Complexity is **O(n)**.
We can use this technique to find max/min k-subarray, XOR, product, sum, etc. Refer sliding window problems for such problems.
https://youtu.be/9-3BXsfrpbY?list=PLqM7alHXFySEQDk2MDfbwEdjd2svVJH9p

This article is contributed by **Kanika Thakral**. If you like GeeksforGeeks and would like to contribute, you can also write an article using write.geeksforgeeks.org or mail your article to review-team@geeksforgeeks.org. See your article appearing on the GeeksforGeeks main page and help other Geeks.

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