Sliding Window: Introduction

Let's go over the Sliding Window pattern, its real-world applications, and some problems we can solve with it.

We'll cover the following

Overview

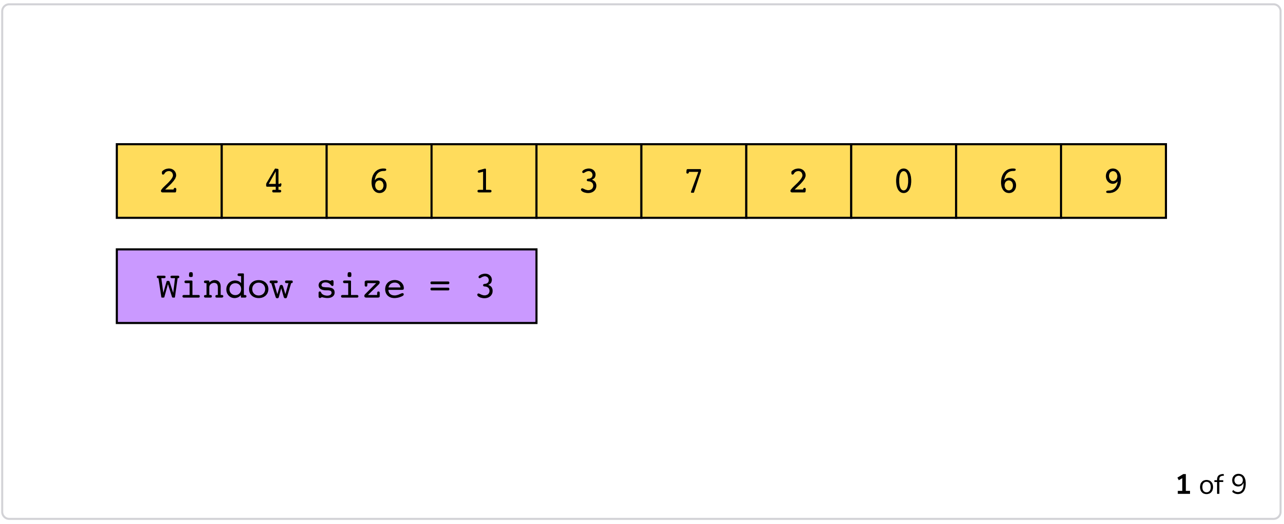
The **sliding window** pattern is a computational method aimed at reducing the use of nested loops in an algorithm. It's a variation of the two pointers pattern, where the pointers can be used to set window bounds.

A window is a sublist formed over a part of an iterable data structure. It can be used to slide over the data in chunks corresponding to the window size. The sliding window pattern allows us to process the data in segments instead of the entire list. The segment or window size can be set according to the problem's requirements. For example, if we have to find three consecutive integers with the largest sum in an array, we can set the window size to 3. This will allow us to process the data three elements a time.

Why is this method more efficient? It isn't if, for each window, we iterate over all the elements of the window because that gives us the same $O(k$ time complexity.

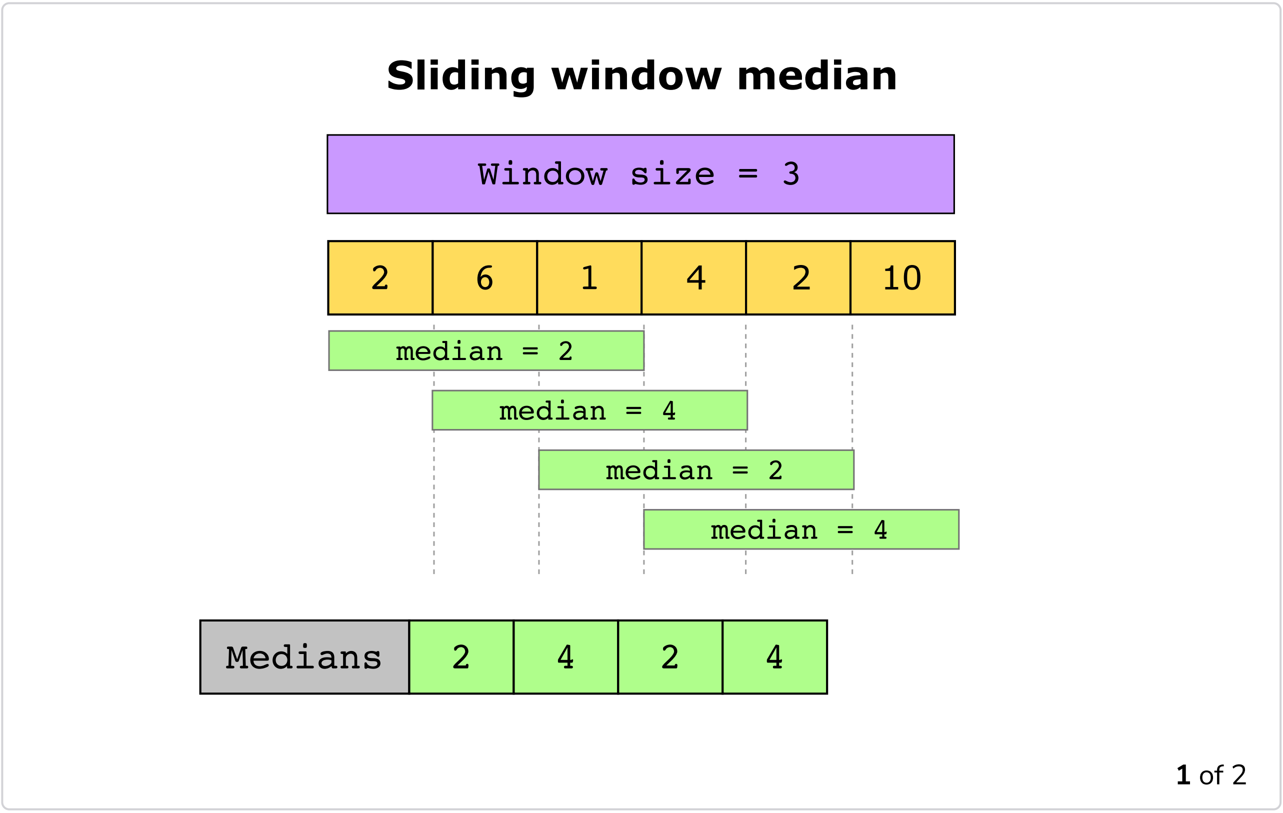
Instead, what if we focused on the element entering the window and the one leaving it? For example, after calculating the sum of the first three elements, we move the window one step forward, subtract the element that is no longer in the window from the sum, and add the new element that has entered it. Next we check if the new sum is greater than the first. If it is, we update the max sum found so far. Now, each time we move the window forward, we perform at most four operations, reducing the time complexity to $O(4n)$, that is, $O(n)$.

The following illustration shows how the window moves along an array:



Examples

The following examples illustrate some problems that can be solved with this approach:



Does my problem match this pattern?

- Yes, if both these conditions are fulfilled:
    - The problem requires repeated computations on a contiguous set of data elements (a subarray or a substring), such that the window moves across the input array from one end to the other. The size of the window may be fixed or variable, depending on the requirements of the problem. The repeated computations may be a direct part of the final solution, or they may be intermediate steps building up towards the final solution.
    - The computations performed every time the window moves take $O(1)$ time or are a slow-growing function, such as log, of a sma variable, say k, where $k \ll n$.
- No, if either of these conditions are fulfilled:
    - The input data structure does not support random access.
    - You have to process the entire data without segmentation.

Real-world problems

Many problems in the real world use the sliding window pattern. Let’s look at some examples.

- **Telecommunications:** Find the maximum number of users

sliding window.

- **E-commerce:** Given a dataset of product IDs in the order they were viewed by the user and a list of products that are likely to be similar, find how many times these products occur together in the dataset.
- **Video streaming:** Given a stream of numbers representing the number of buffering events in a given user session, calculate the median number of buffering events in each one-minute interval.
- **Social media content mining:** Given the lists of topics that two users have posted about, find the shortest sequence of posts by one user that includes all the topics that the other user has posted about.

Strategy time!

Match the problems that can be solved using the Sliding Window pattern.

> **Note:** Select a problem in the left-hand column by clicking it, and then click one of the two options in the right-hand column.

Match The Answer

Select an option from the left-hand side

Locate the 6^{th} largest element in an array.

Sliding Window

Given a string, find its longest substring that includes 5 distinct characters.

Find 3 contiguous integers in an array with the highest sum.

Find safe places for 5 queens on a 5×5 chessboard.

Some other pattern

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Solution: Palindrome L...

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Repeated DNA Seque...

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