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A computer science portal for geeks

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What does 'Space Complexity' mean?

Space Complexity:
The term Space Complexity is misused for Auxiliary Space at many places. Following are the correct definitions of Auxiliary Space and Space Complexity.

Auxiliary Space is the extra space or temporary space used by an algorithm.

Space Complexity of an algorithm is total space taken by the algorithm with respect to the input size. Space complexity includes both Auxiliary space and space used by input.

For example, if we want to compare standard sorting algorithms on the basis of space, then Auxiliary Space would be a better criteria than Space Complexity. Merge Sort uses O(n) auxiliary space, Insertion sort and Heap Sort use O(1) auxiliary space. Space complexity of all these sorting algorithms is O(n)

though.

Please write comments if you find anything incorrect, or you want to share more information about the topic discussed above.

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Batman · 2 months ago

Good point mentioned to differentiate between auxiliary space and input space.

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gansai · 6 months ago

"Merge Sort uses O(n) auxiliary space" -- does it mean that if the input size is n elements, it actually requires almost n extra elements places to ultimately do the sorting? Is my understanding correct? Thanks.

⌃ | ⌄ · Reply · Share ›

> **Anurag Singh** ➔ gansai · 6 months ago
>
> Yes. It uses temporary array of n size while merge (conquer) step.
>
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>
> > **gansai** ➔ Anurag Singh · 6 months ago
> >
> > thanks anurag
> >
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Ashwini Singh · 9 months ago

Ashwini Singh · 9 months ago

@geeksforgeeks

Will function(recursive) stack be counted in auxilary space??

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> **tvs551** → Ashwini Singh · 3 months ago
>
> yes. Auxilary space includes total space which is being used to execute the program.
>
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Amit Kaushik · 10 months ago

System stack is never considered in space complexity

∧ | ∨ · Reply · Share ›

> **kar** → Amit Kaushik · 9 months ago
>
> the variables which we use , or if we define an array are ultimately stored in system stack . Therefore it is a part of space complexity.
>
> ∧ | ∨ · Reply · Share ›

Krishna Vedulla · a year ago

i think auxiliary space of merge sort should be O(nlogn)
can anyone please explain this auxiliary space in detail..
like how auxiliary space of merge sort will be O(n) ??

∧ | ∨ · Reply · Share ›

> **KingKai** → Krishna Vedulla · 3 months ago
>
> Space Complexity:
> In each recursion step, the space required will half the previous step,
> n+(n/2)+(n/4)+(n/8)+.... = n(1+1/2+1/4+1/8+...) = 2n = O(n)
>
> 2 ∧ | ∨ · Reply · Share ›

> **jitendrak** → Krishna Vedulla · a year ago
>
> trace the hand run of a merge sort (using tree) and you will see only n (n = size of array) extra (and thus auxiliary space) space is required.
>
> ∧ | ∨ · Reply · Share ›

Siddhartha · a year ago

There are two types to compute the space complexity.
1. Fixed part
2. Variable part.
So can you tell me about that.
Thanks

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thyagu · 2 years ago

can you cheat worst case running time of an algorithm

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csmajor → thyagu · a year ago

To make it slower or faster than its worst-case? Typically, an algorithm is almost always faster than its worst-case running time. Worst-case is the limit of how slow it can be, not how fast. As for making it slower than its worst-case, I don't see how that would be possible without "artificial" means of slowing it down, such as explicit additions to the code that would pause it or make it wait for things other than its typical computation.

2 ∧ | ∨ · Reply · Share ›

sawan · 2 years ago

can we directly exit from recursion and return to the calling fn.
like in case of recursive version of linear search.

```
#include
int i;
int linear_search(int arr[], int x, int n) {
if(arr[i]==x)
return i;
if(i>=n)
return -1;
i++ ;
return linear_search(arr,x,n);
}
int main()
{
int arr[]={2,12,43,12,3,23,14,23,43,56,68,4,13};
int size=sizeof(arr)/sizeof(int);
int x=52;
printf("%d is presnt in array at index %d",x,linear_search(arr,x,size));
return 0;
}
```

here in function linear_search....after getting the index, is there any way to directly go to main.

∧ | ∨ · Reply · Share ›

Sen · 2 years ago

Could you please have one tutorial on the 3 notations used for complexity analysis i.e. (Theta,Ohm and Big-O) ?
Whats exact difference between these and which to use when ?

/* Paste your code here (You may **delete** these lines **if not** writing code) */

```
/* Paste your code here (You may delete these lines if not writing code) */
```

1 ∧ | ∨ • Reply • Share ›

kartikaditya · 3 years ago

In recursive algo's like merge sort, the compiler may end up eating space for stack frames, which is important from a programming point of view.

How do I classify such external space?

2 ∧ | ∨ • Reply • Share ›

lp · 4 years ago

Is there any sorting algorithm whose Space Complexity is not O(n)?

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kartik → lp · 4 years ago

Space complexity of almost all standard sorting algorithms is at least O(n). There are few exceptions like External Sorting.

∧ | ∨ • Reply • Share ›

Jagat → kartik · 2 years ago

I wouldn't worry about the "in-memory" space used by the external sorting algorithm which is usually considered to be the whole RAM size per basic chunk, for optimal I/O.
Having said that, external merge process would still require O(n) auxiliary space on the disk since in-place merge is only of theoretical interest and anything more than O(n) is not necessary.

∧ | ∨ • Reply • Share ›

lp · 4 years ago

How much auxiliary space is needed for Quick Sort?

∧ | ∨ • Reply • Share ›

Jagat → lp · 2 years ago

Quick sort requires no "explicit" auxiliary space since all the sorting happens in place. However, because of the recursive calls, which can go upto a depth of O(n) in the worst case and O(log n) in the average case, the auxiliary space required by the system stack can be considered to be O(n).

1 ∧ | ∨ • Reply • Share ›

kartik → lp · 4 years ago

Quick Sort needs O(n) extra space in worst case and O(Logn) in average case. Worst case happens when all elements are sorted.

∧ | ∨ • Reply • Share ›

ibn → kartik · a year ago

Not sure I see it clear. If Quick sort take O(n) aux space, what would merge sort takes?

n aux space + 2n recursive call (assume complete binary tree) = 3n aux space. Am I right?

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