

Common Data Structure Operations

| Data Structure | Time Complexity | | | | | | | | Space Complexity |
|---------------------------|-----------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|------------------|
| | Average | | | | Worst | | | | Worst |
| | Access | Search | Insertion | Deletion | Access | Search | Insertion | Deletion | |
| <u>Array</u> | $O(1)$ | $O(n)$ | $O(n)$ | $O(n)$ | $O(1)$ | $O(n)$ | $O(n)$ | $O(n)$ | $O(n)$ |
| <u>Stack</u> | $O(n)$ | $O(n)$ | $O(1)$ | $O(1)$ | $O(n)$ | $O(n)$ | $O(1)$ | $O(1)$ | $O(n)$ |
| <u>Queue</u> | $O(n)$ | $O(n)$ | $O(1)$ | $O(1)$ | $O(n)$ | $O(n)$ | $O(1)$ | $O(1)$ | $O(n)$ |
| <u>Singly-Linked List</u> | $O(n)$ | $O(n)$ | $O(1)$ | $O(1)$ | $O(n)$ | $O(n)$ | $O(1)$ | $O(1)$ | $O(n)$ |
| <u>Doubly-Linked List</u> | $O(n)$ | $O(n)$ | $O(1)$ | $O(1)$ | $O(n)$ | $O(n)$ | $O(1)$ | $O(1)$ | $O(n)$ |
| <u>Skip List</u> | $O(\log(n))$ | $O(\log(n))$ | $O(\log(n))$ | $O(\log(n))$ | $O(n)$ | $O(n)$ | $O(n)$ | $O(n)$ | $O(n \log(n))$ |
| <u>Hash Table</u> | N/A | $O(1)$ | $O(1)$ | $O(1)$ | N/A | $O(n)$ | $O(n)$ | $O(n)$ | $O(n)$ |
| <u>Binary Search Tree</u> | $O(\log(n))$ | $O(\log(n))$ | $O(\log(n))$ | $O(\log(n))$ | $O(n)$ | $O(n)$ | $O(n)$ | $O(n)$ | $O(n)$ |
| <u>Cartesian Tree</u> | N/A | $O(\log(n))$ | $O(\log(n))$ | $O(\log(n))$ | N/A | $O(n)$ | $O(n)$ | $O(n)$ | $O(n)$ |
| <u>B-Tree</u> | $O(\log(n))$ | $O(\log(n))$ | $O(\log(n))$ | $O(\log(n))$ | $O(\log(n))$ | $O(\log(n))$ | $O(\log(n))$ | $O(\log(n))$ | $O(n)$ |
| <u>Red-Black Tree</u> | $O(\log(n))$ | $O(\log(n))$ | $O(\log(n))$ | $O(\log(n))$ | $O(\log(n))$ | $O(\log(n))$ | $O(\log(n))$ | $O(\log(n))$ | $O(n)$ |
| <u>Splay Tree</u> | N/A | $O(\log(n))$ | $O(\log(n))$ | $O(\log(n))$ | N/A | $O(\log(n))$ | $O(\log(n))$ | $O(\log(n))$ | $O(n)$ |
| <u>AVL Tree</u> | $O(\log(n))$ | $O(\log(n))$ | $O(\log(n))$ | $O(\log(n))$ | $O(\log(n))$ | $O(\log(n))$ | $O(\log(n))$ | $O(\log(n))$ | $O(n)$ |
| <u>KD Tree</u> | $O(\log(n))$ | $O(\log(n))$ | $O(\log(n))$ | $O(\log(n))$ | $O(n)$ | $O(n)$ | $O(n)$ | $O(n)$ | $O(n)$ |

Array Sorting Algorithms

| Algorithm | Time Complexity | | | Space Complexity |
|-----------------------|-----------------|-------------------|-------------------|------------------|
| | Best | Average | Worst | Worst |
| <u>Quicksort</u> | $O(n \log(n))$ | $O(n \log(n))$ | $O(n^2)$ | $O(\log(n))$ |
| <u>Mergesort</u> | $O(n \log(n))$ | $O(n \log(n))$ | $O(n \log(n))$ | $O(n)$ |
| <u>Timsort</u> | $O(n)$ | $O(n \log(n))$ | $O(n \log(n))$ | $O(n)$ |
| <u>Heapsort</u> | $O(n \log(n))$ | $O(n \log(n))$ | $O(n \log(n))$ | $O(1)$ |
| <u>Bubble Sort</u> | $O(n)$ | $O(n^2)$ | $O(n^2)$ | $O(1)$ |
| <u>Insertion Sort</u> | $O(n)$ | $O(n^2)$ | $O(n^2)$ | $O(1)$ |
| <u>Selection Sort</u> | $O(n^2)$ | $O(n^2)$ | $O(n^2)$ | $O(1)$ |
| <u>Tree Sort</u> | $O(n \log(n))$ | $O(n \log(n))$ | $O(n^2)$ | $O(n)$ |
| <u>Shell Sort</u> | $O(n \log(n))$ | $O(n(\log(n))^2)$ | $O(n(\log(n))^2)$ | $O(1)$ |
| <u>Bucket Sort</u> | $O(n+k)$ | $O(n+k)$ | $O(n^2)$ | $O(n)$ |
| <u>Radix Sort</u> | $O(nk)$ | $O(nk)$ | $O(nk)$ | $O(n+k)$ |
| <u>Counting Sort</u> | $O(n+k)$ | $O(n+k)$ | $O(n+k)$ | $O(k)$ |
| <u>Cubesort</u> | $O(n)$ | $O(n \log(n))$ | $O(n \log(n))$ | $O(n)$ |