Practical 6: Advanced Sorting Algorithms

What am I doing today?

Today’s practical focuses on:

1. Implement Quicksort from pseudo-code
2. Develop a separate Enhanced QuickSort algorithm
3. Assess the performance difference between QuickSort and Enhanced QuickSort

Instructions

Try all the questions. Ask for help from the demonstrators if you get stuck.

Algorithmic Development

Part 1

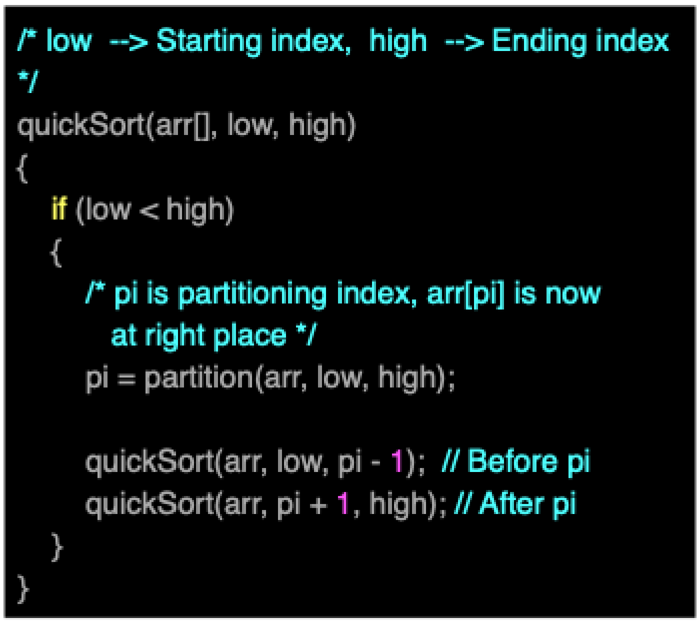
Let’s start by implementing a version of the Quick Sort algorithm (using the pseudo-code below) that sort values in ascending order.

First implement Quick Sort:

Remember Quick Sort is an algorithm that takes a divide-and-conquer approach. The steps are:

1. Pick an element, called a pivot, from the list.
2. Reorder the list so that all elements which are less than the pivot come before the pivot and so that all elements greater than the pivot come after it (equal values can go either way). After this partitioning, the pivot is in its final position. This is called the partition operation.
3. Recursively sort the sub-list of lesser elements and the sub-list of greater elements.To implement QuickSort you will need to create two functions:

1. **QuickSort**



```
/* low  --> Starting index,  high  --> Ending index
*/
quickSort(arr[], low, high)
{
    if (low < high)
    {
        /* pi is partitioning index, arr[pi] is now
           at right place */
        pi = partition(arr, low, high);

        quickSort(arr, low, pi - 1);  // Before pi
        quickSort(arr, pi + 1, high); // After pi
    }
}
```

2. **Partition**

```
partition (arr[], low, high)
{
   // pivot (Element to be placed at right position)
   pivot = arr[high];

   i = (low - 1)  // Index of smaller element
   for (j = low; j <= high- 1; j++)
   {
      // If current element is smaller than the pivot
      if (arr[j] < pivot)
      {
         i++;    // increment index of smaller element
         swap arr[i] and arr[j]
      }
   }
   swap arr[i + 1] and arr[high])
   return (i + 1)
}
```

Part 2

Write a second version of QuickSort (you can call it **enhancedQuickSort**) that implements the two improvements that we covered in the lecture:

1) Similar to your mergesort implementation last week, add a cutoff for small subarrays (e.g., <10) and use the insertion sort algorithm you wrote before to handle them. We can improve most recursive algorithms by handling small cases differently.

   Pseudo-code:
   ```
   if (hi <= lo + CUTOFF) {
       insertionSort(array, lo, hi);
           return;
         }
   ```

2) As we saw in the lecture, random shuffling the input array first improves performance and protects against the worse case performance. Add a shuffle function that takes the input array and shuffles the elements. You can use the helper shuffle algorithms in the rep.
3) As we saw in the lecture, choosing a partition where the value is near the middle or exactly the middle of the elements in the arrays values means our sort will perform better. In quicksort with median-of-three partitioning the pivot item is selected as the median between the first element, the last element, and the middle element (decided using integer division of n/2). In the cases of already sorted lists this should take the middle element as the pivot thereby reducing the inefficiency found in normal quicksort.

   Look at the first, middle and last elements of the array, and choose the median of those three elements as the pivot (e.g,, int median = medianOf3(a, lo, lo + (hi-lo)/2, hi);

Part 3

Compare the performance of MergeSort (from last week), QuickSort and QuickSortEnhanced on a range of inputs (N= 10, 1000, 10000, 100000 etc.) and graph the results of your experiments.