Assignment 2

Akhil Patil | ap1604

Q1 ->

Table1 : Number of Comparisons – data0.* (Sorted Dataset)

Dataset	Shell Sort	Insertion Sort
data0.1024	3061	1023
data0.2048	6133	2047
data0.4096	12277	4095
data0.8192	24565	8191
data0.16384	49141	16383
data0.32768	98293	32767

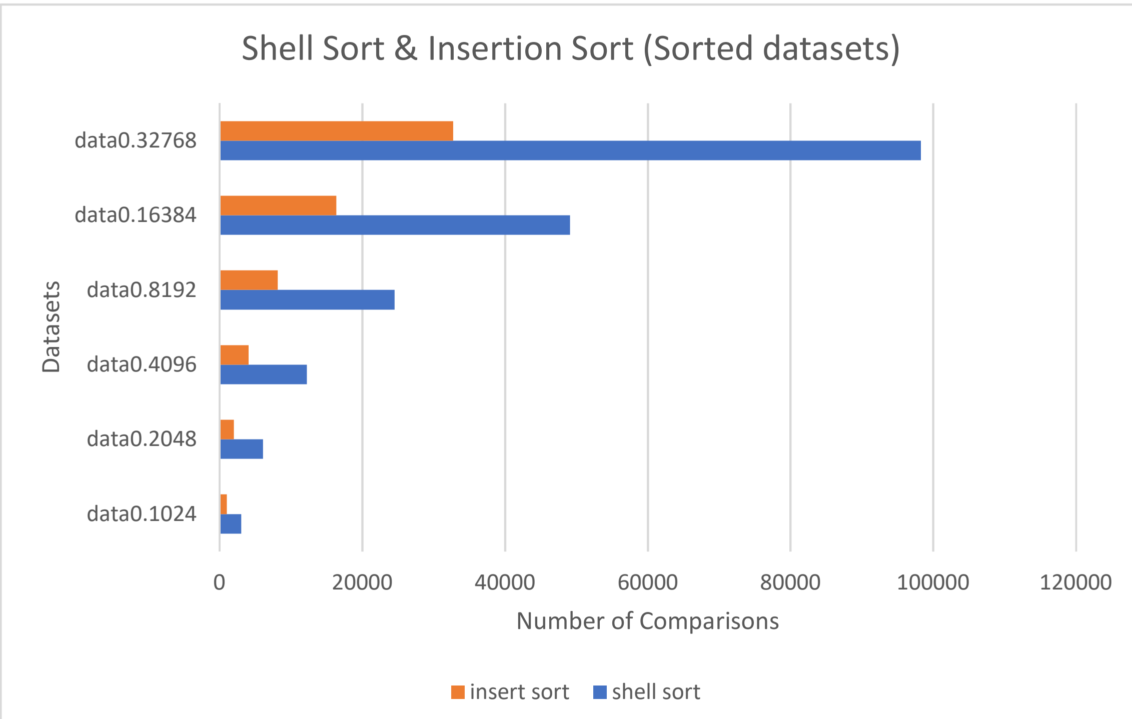
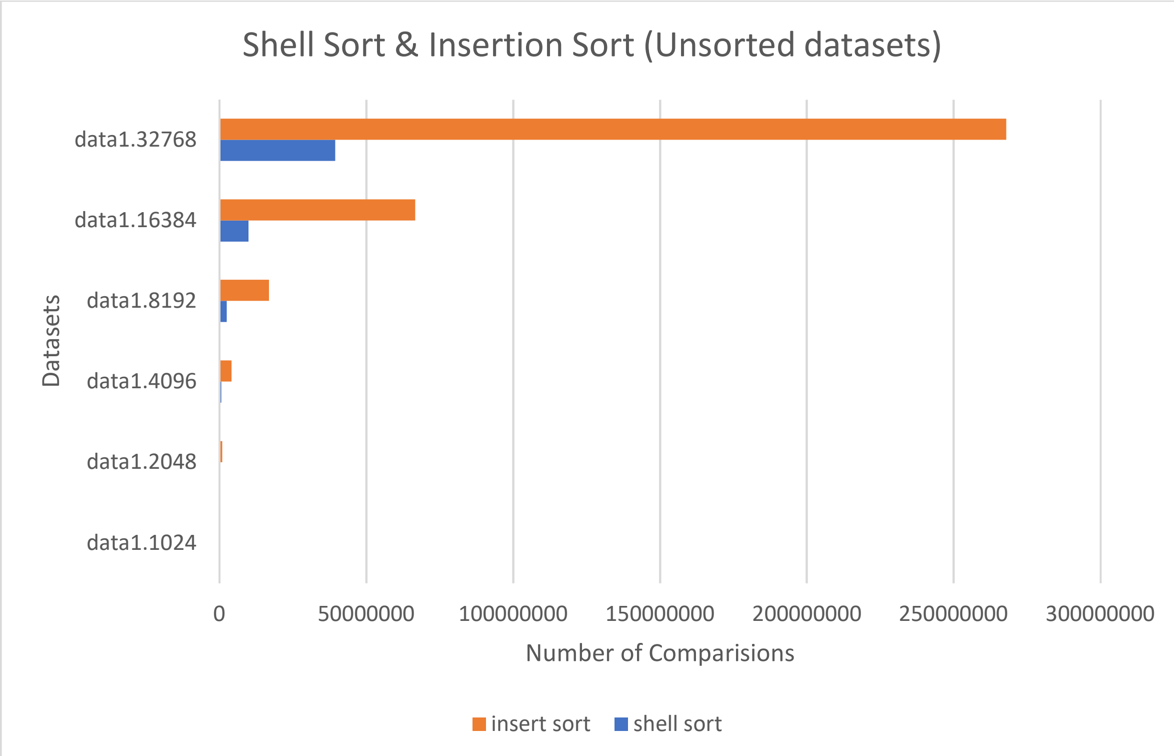


Table2: Number of Comparisons – data1.* (Unsorted Dataset)

Dataset	Shell Sort	Insert Sort
data1.1024	46728	265553
data1.2048	169042	1029278
data1.4096	660619	4187890
data1.8192	2576270	16936946
data1.16384	9950922	66657561
data1.32768	39442456	267966668



Analysis:

For the sorted datasets, it is the best case for insertion sort where it makes N-1 comparisons and 0 exchanges. But in the case of shell sort it must go through the whole array for different values of h. when h is 1 shell sort scans the whole array where it has to make N-1 comparisons. From the graph we can see that shell sort requires almost more double number of comparisons than Insertion sort. So, in sorted dataset case Insertion sort performs better than shell sort.

For the Unsorted datasets, shell short out performs insertion sort because it avoids the long-distance sorting when h=1, for the higher vales of h, long distance disorder is fixed, and array becomes partially sorted. While for Insertion sort it has scan through the whole array and place the element at correct place in sort half by comparing it to each element in sorted half array. So, the number of comparisons required for insertion sort are way more than shell sort. In this case shell sort performs better than insertion sort.

Q2 ->

Table3 : Running Time-Data Size

Dataset	Running Time(μs)
1024	360
2048	489
4096	738
8192	1542
16384	3549
32768	7182

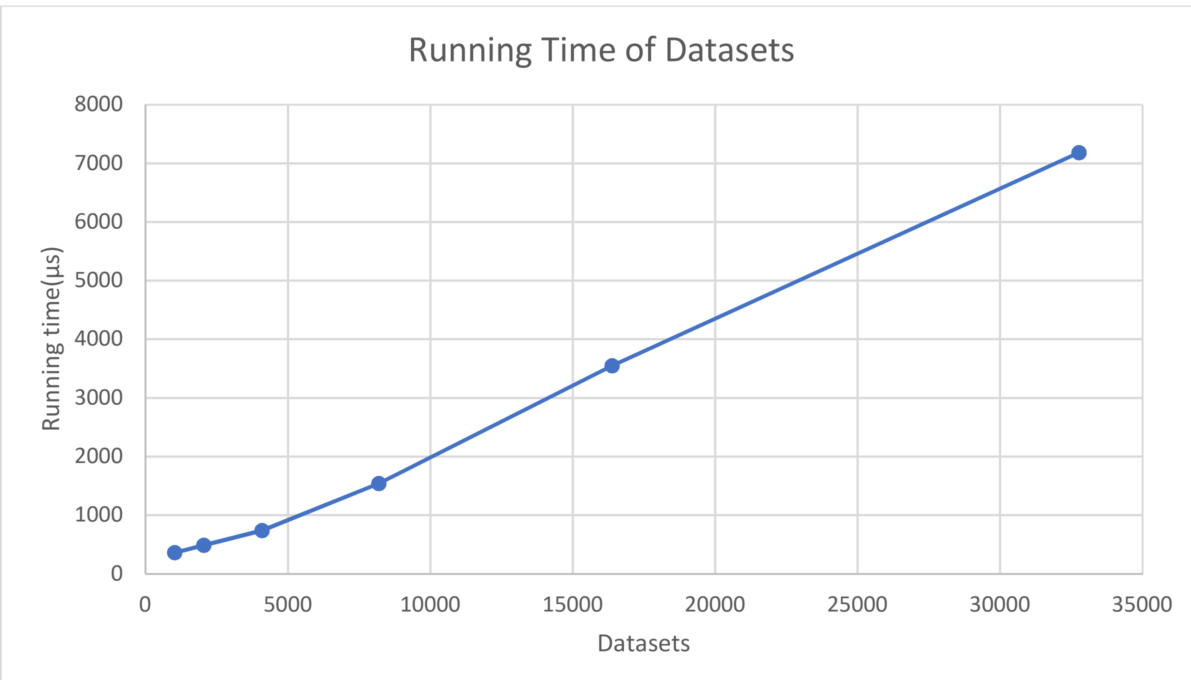


Table4 : Number of inversions – Dataset

Dataset	Number of Inversions
data.1024	264541
data.2048	1027236
data.4096	4183804
data.8192	16928767
data.16384	66641183
data.32768	267933908

Analysis:

To count number of inversions in an array I used recursive merge sort to sort and count the number of inversions with the cost of O(NlogN). For getting the number of inversions we first divide the array in two parts left and right and compare elements in right and left subarrays. When array[left] > array[right] , then there are (mid – i+1) pairs of inversions.

From the plot we can interpret that running time and size of datasets are directly related. i.e. increase in dataset size increases the time like merge sort . Also, we can say that as number of inversion pairs increase , time also increases. Time complexity for this algorithm is O(NlogN).

Q3 ->

For this question, I have implemented the counting sort method to sort the numbers of the array. The regular counting sort method sorts the elements at the cost of O(n +r). n is the size of array and r is the largest number in the array.

But in this scenario, we have advance knowledge of the elements of the array . So, I created a enhanced version of counting sort which first calculates the number of times the elements are repeated like 1 is repeated for 1024 times and stores it in a temp array. Then we create the array from the smallest element to the size which we counted, and another number appends the array for the count of occurrences.

This implementation costs O(N) which is same as the bubble and insertion sort. So, For this question I think Bubble sort, insertion sort and enhanced version of counting sort are the efficient algorithms for sorting.

Q4 - >

Table5 : Number of Comparisons(UB and BU) – Sorted Dataset

Datasets	Number of Comparisons(UB)	Number of Comparisons(BU)
data0.1024	25600	25600
data0.2048	56320	56320
data0.4096	122880	122880
data0.8192	266240	266240
data0.16384	573440	573440
data0.32768	1228800	1228800

Table6 : Number of Comparisons(UB and BU) – Unsorted Dataset

Datasets	Number of Comparisons(UB)	Number of Comparisons(BU)
data1.1024	44770	25600
data1.2048	99670	56320
data1.4096	219720	122880
data1.8192	480370	266240
data1.16384	1043475	573440
data1.32768	2250660	1228800

Analysis:

From the Table5 we can say that the number of comparisons in Best case i.e. for sorted dataset required by both the implementations of merge sort one with recursive(UB) and the iterative methods(BU) are same with time complexity of O(1/2 * NlogN)

For unsorted datasets, from the table6 we can observe that Bottom Up approach requires the same amount of comparisons as for the sorted arrays because the size is same as for the datasets. While in case of Top bottom recursive approach requires more comparisons than that of sorted dataset. Here the complexity of both is O(NlogN).

From the above results we can say that both the approaches top-bottom and bottom-Up performs same for best case and Bottom up implementation of merge sort performs better in Average case than top-bottom approach.

Q5 ->

Table7 - Number of Comparisons—both datasets

dataset	merge sort(UB)	merge sort(BU)	quick sort	Quick sort cutoff=3	quick sort cutoff=7	quick sort cutoff=64
data0.1024	25600	25600	7692	7948	7563	5048
data0.2048	56320	56320	17421	17933	17164	12137
data0.4096	122880	122880	38926	39950	38413	28362
data0.8192	266240	266240	86031	88079	85006	64907
data0.16384	573440	573440	188432	192528	186383	146188
data0.32768	1228800	1228800	409617	417809	405520	325133
data1.1024	44770	25600	6486	6764	7042	15231
data1.2048	99670	56320	13577	14151	14789	29864
data1.4096	219720	122880	30473	31647	32945	66439
data1.8192	480370	266240	67101	68956	71895	140654
data1.16384	1043475	573440	152514	157224	162165	293073
data1.32768	2250660	1228800	324659	333953	344084	601975

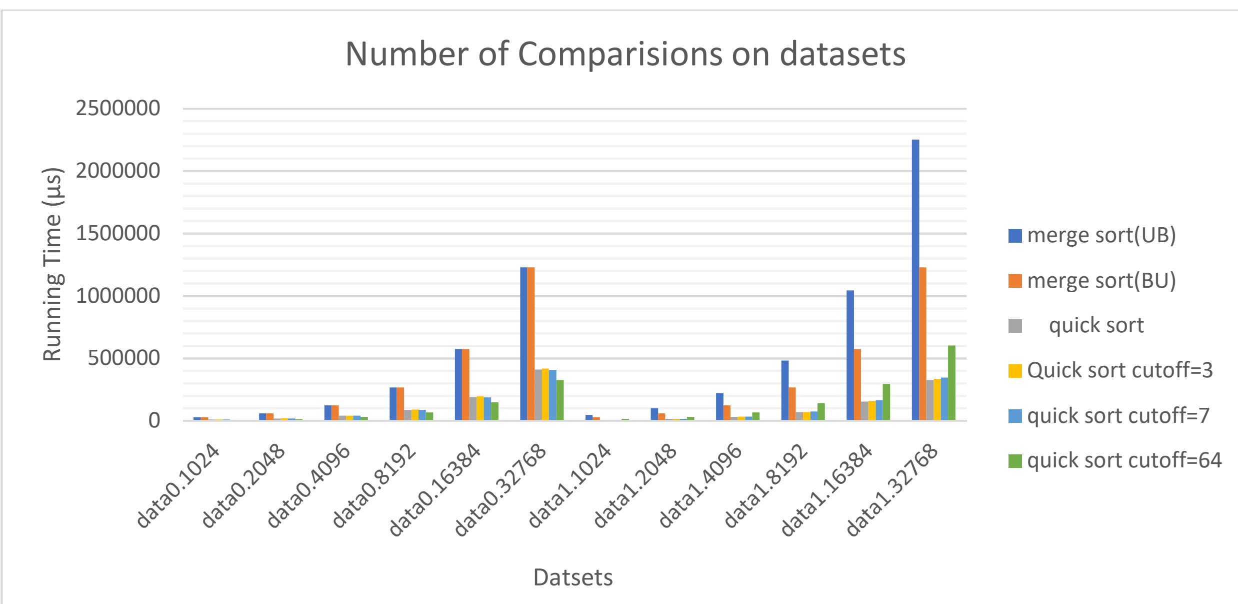
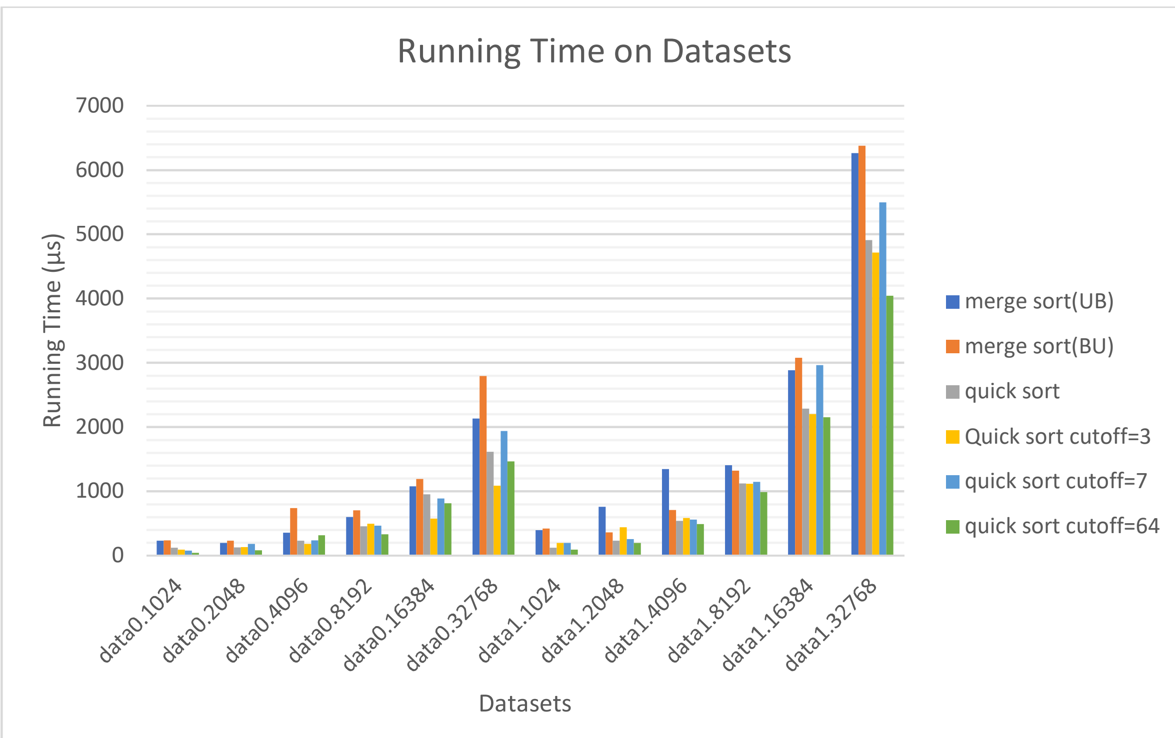


Table8 - (Running Time—Both Dataset)

dataset	merge sort(UB)	merge sort(BU)	quick sort	Quick sort cutoff=3	quick sort cutoff=7	quick sort cutoff=64
data0.1024	229	235	120	90	76	43
data0.2048	194	228	128	130	178	80
data0.4096	354	736	228	178	237	313
data0.8192	597	703	454	494	464	330
data0.16384	1076	1193	951	572	889	811
data0.32768	2131	2795	1612	1085	1938	1462
data1.1024	395	421	120	194	195	90
data1.2048	759	360	232	437	253	195
data1.4096	1344	710	538	583	559	489
data1.8192	1405	1322	1122	1117	1148	986
data1.16384	2884	3076	2284	2199	2963	2151
data1.32768	6263	6376	4910	4715	5495	4041



Analysis:

To compare merge sort and quick sort I am using number of comparisons made in the execution and the time of execution. Now since the dataset of data0 is sorted and data1 is unsorted , but it is not the worst case of descending, so I am avoiding the shuffling of array in quicksort.

From Table7 , we can see that quick sort has a smaller number of comparisons made to sort both the datasets. Also, from table8 we can say that the running time is less than merge sort. So, overall quick sort performs better based on time and number if comparisons.

For sorted dataset insertion sort performs better in smaller sub arrays while quick sort calls recursively for sorting in small arrays. So, when cutoff value is set , the algorithm does better. Insertion takes O(n) for the sorted array while quick sort takes O(nlogn). So the insertion sort performs better at data0 series. So, when the cutoff value is set to 7, algorithm performs better than without cutoff because of the use of insertion sort for smaller arrays. And as we increase the value of cutoff value like in this case, I have done cutoff value of 64 which gets the best results among all other algorithms in every case. So, Higher cutoff value gets better results.