ASSIGNMENT2

Data Structure & Algorithm

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Assignment 2

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Q1.

Table:Number of Comparisons – Dataset (Already Sorted)

dataset	shell sort	insert 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

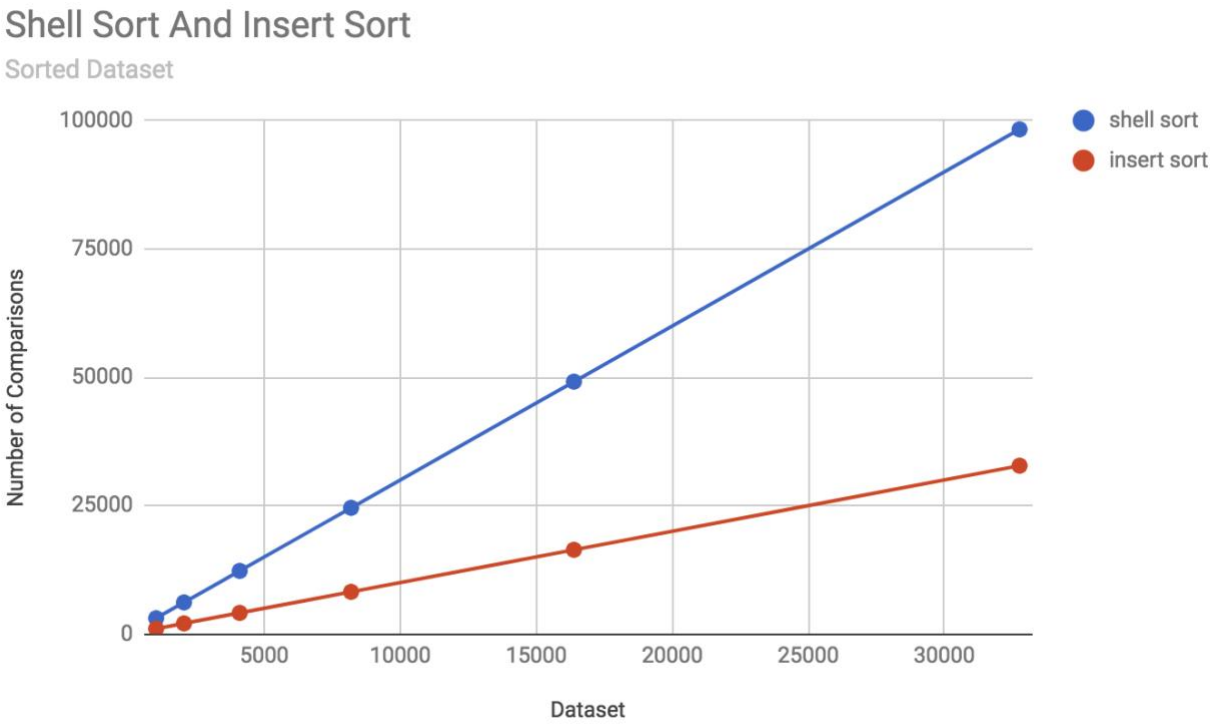
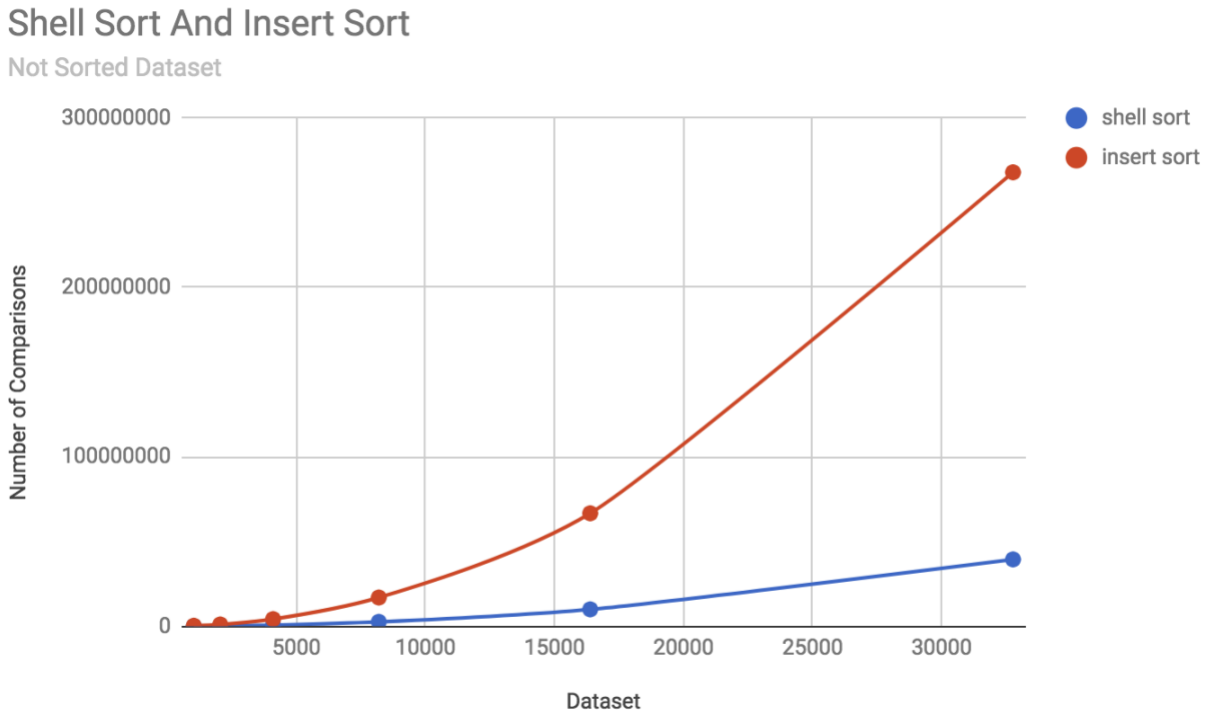


Table:Number of Comparisons – Dataset (Not Sorted)

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



Analyze：

For the first data set which is already sorted. It is the best case for insertion sort. The number of comparisons is always N-1. But for the shell sort, it has to scan the array for several times when h equals to different value. When h=1, the number of comparisons has already been N-1. So for sorted array, insert sort does better than the shell sort.

For the second dataset which is randomly given. Shell sort does way better than insert sort. Because it efficiently avoid the long-distance 1-sort. It allows elements to move long distance by beginning with large h-value, which can reduce large amounts of disorder quickly. Then the data becomes partially sorted. In this situation, smaller h-sort can solve the problem efficiently. So that's why shell sort works better than insert sort in random given array.

Q2.

Table Name: Running Time-Data Size

dataset	Running Time(s)
1024	302
2048	514
4096	683
8192	1052
16384	2668
32768	5043

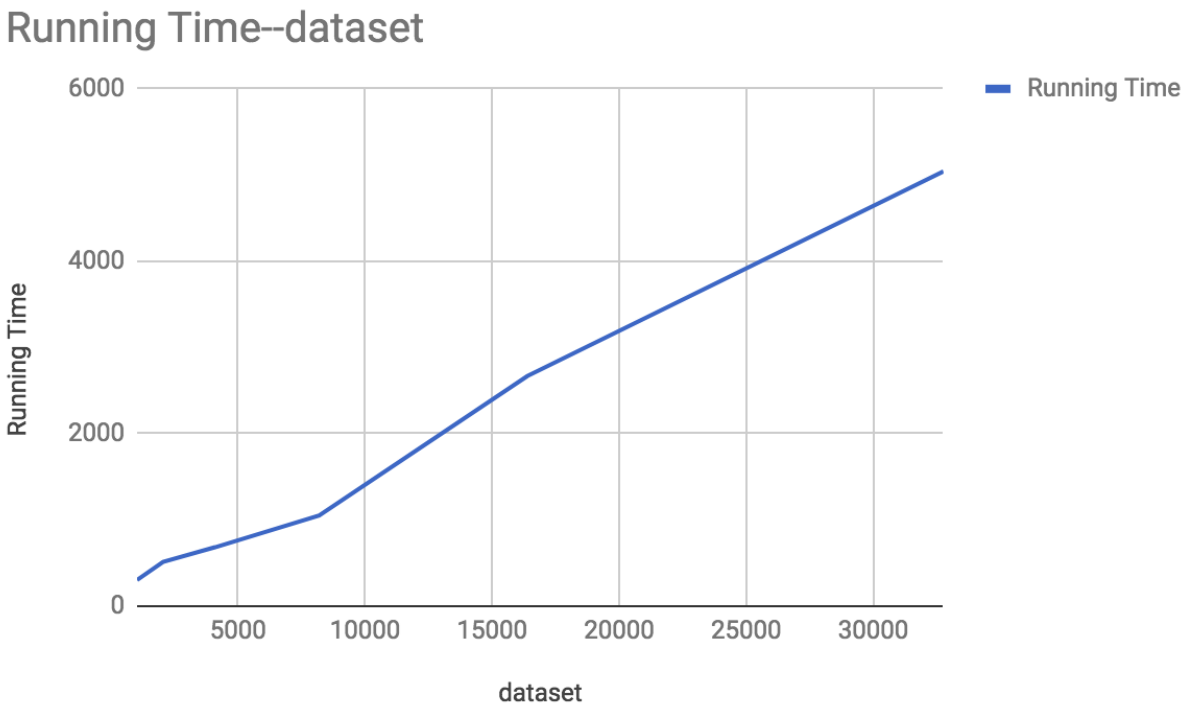


Table Name: Number of inversions – Dataset

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

Discuss:

For this question, it just to count the number of the inversions in one array. I use the thought of merge sort to count the number of inversion in complexity of O(nlogn). The key part o the algorithms is as follows:

When merge two subarray, assume i is the index for left subarray, j is the index of the right array. When array[i]>array[j]. For all the element in the left array at the right sort of array[i] is bigger than array[j] . So under this circumstance, there are mid-i+1 pair of inversions. And same for rest of them.

Basically, as you can see from the graph, the time complexity for this algorithm is the same with merge sort. So it is O(nlogn).

The result of the running time is the average of 5 times calculationg.

Q3.

For this problem, I use the counting sort method. Its' time complexity is only o(n+r). The n represents the number of elements in the array. The r represents the biggest number in the array. The space complexity is O(r).
But for this question, we can assume we already know the values in the array in advance. So for the counting array ,we can directly create a size 4 array, and use the array record the number of times each value. And use the count array to output the result.
Counting sort is not a comparison based sort, so for the time complexity, it is smaller than any comparison based sort method. So for this problem, I think it is the most efficient sorting method.
Basically, the complexity of the modified counting sort here is O(n). Also, since the array is already sorted, both the bubble sort and the insertion sort perform as O(n) algorithm here, too. So for this question , I think modified counting sort, bubble sort and the insertion sort are the most efficient algorithm.

Q4.

Table: Number of Comparisons(UB and BU) -- Dataset

dataset	number of comparisons(UB)	number of comparisons(BU)
data0.1024	5120	5120
data0.2048	11264	11264
data0.4096	24576	24576
data0.8192	53248	53248
data0.16384	114688	114688
data0.32768	245760	245760
data1.1024	8954	8954
data1.2048	19934	19934
data1.4096	43944	43944
data1.8192	96074	96074
data1.16384	208695	208695
data1.32768	450132	450132

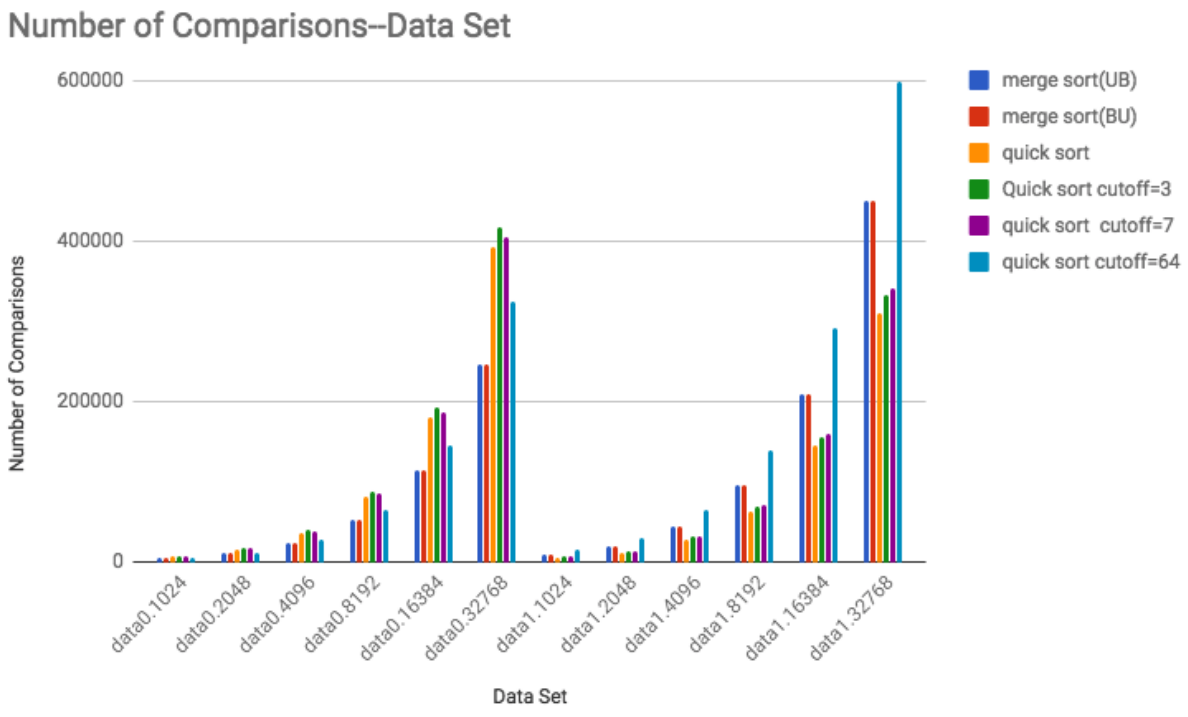
Explain:
As we can see, the number of comparisons needed for UB is same with BU's. Because when number of element is the power of 2. Both the number of comparisons and the number of array access needed for BU and UB is same, just different at the order.

Q5.

Table(Number of Comparisons--dataset)

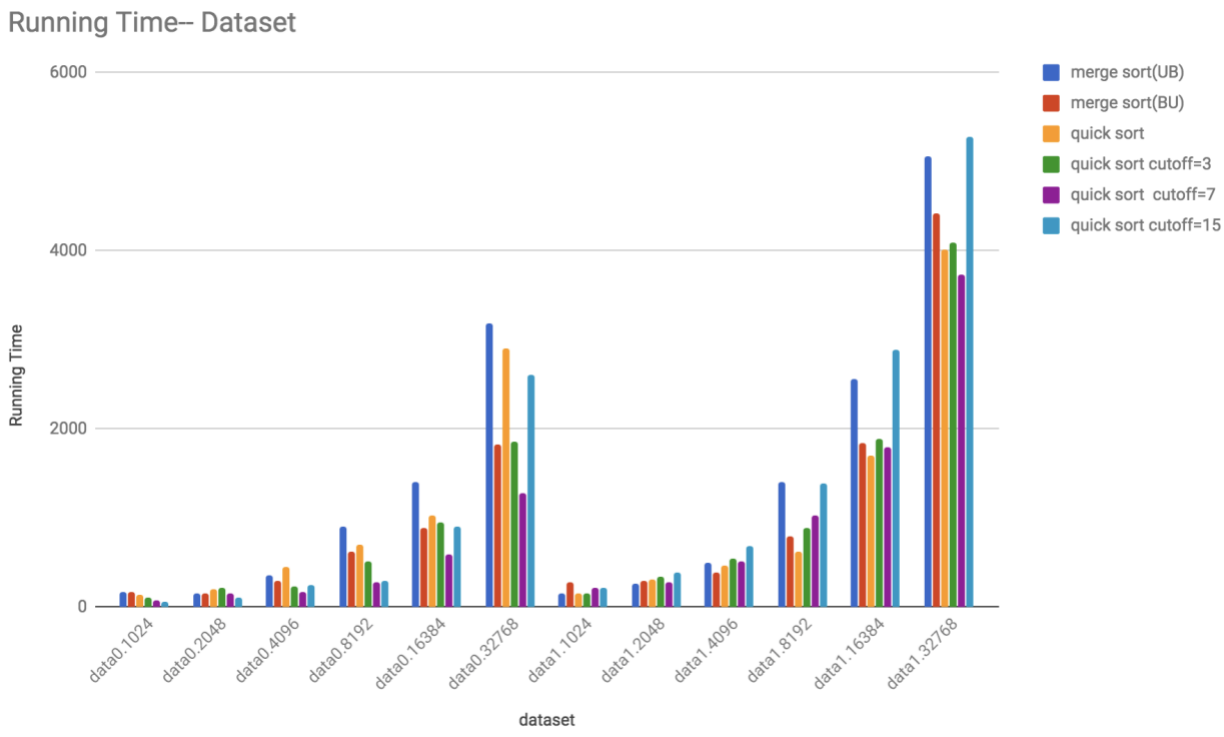
dataset	merge sort(UB)	merge sort(BU)	quick sort	Quick sort cutoff=3	quick sort cutoff=7	quick sort cutoff=64
data0.1024	5120	5120	7181	7948	7567	5048
data0.2048	11264	11264	16398	17933	17168	12137
data0.4096	24576	24576	36879	39950	38417	28362
data0.8192	53248	53248	81936	88079	85010	64907
data0.16384	114688	114688	180241	192528	186387	146188
data0.32768	245760	245760	393234	417809	405524	325133
data1.1024	8954	8954	6046	6716	7005	15231
data1.2048	19934	19934	12704	14033	14637	29482
data1.4096	43944	43944	28724	31399	32562	65785
data1.8192	96074	96074	63576	68956	71200	139050
data1.16384	208695	208695	145509	156274	160686	290796
data1.32768	450132	450132	310593	332125	341283	598193

From this table, we can plot a graph:



Table(Running Time--Dataset)

dataset	merge sort(UB)	merge sort(BU)	quick sort	Quick sort cutoff=3	quick sort cutoff=7	quick sort cutoff=64
data0.1024	168	173	99	60	101	53
data0.2048	155	150	134	81	181	98
data0.4096	347	286	234	119	287	247
data0.8192	900	627	457	256	557	294
data0.16384	1407	892	1009	761	962	896
data0.32768	3188	1828	1960	1496	2468	2613
data1.1024	152	269	106	187	218	87
data1.2048	255	294	324	493	267	764
data1.4096	497	391	740	744	625	450
data1.8192	1405	793	936	852	1459	943
data1.16384	2556	1840	2571	2043	3141	2171
data1.32768	5065	4425	5268	3840	5974	5964



For this question, we already know the data0 series data set is already sorted, the data1 series data set is unsorted and is not the worst case. So I don't shuffle the array in the quicksort.
I compare both the number of comparisons and the running time. Here I use the running time to compare the performance of the runtime complexity. Since the runtime complexity is estimated by the elementary operations of the algorithms, except for the comparisons, it still has the array access to consider. So running time is more considerable way to estimate the runtime complexity here.
As we can see, for quicksort, it performs worse than merge sort(Bottom-up) better than merge sort(Top-Down) at the already sorted array and performs better than merge sort at the random array.

Because in the small array, the insertion sort is quicker than quick sort, since even in a very small subarray, quicksort still always keeps calling itself. So when we set a cutoff value to turn to insertion sort, the algorithm will do better. Also, since the insertion sort is O(n) algorithm at already sorted array, and the quick sort is O(nlogn) at the already sorted array. So the insertion sort performs better at data0 series.
So when I set the cutoff value = 7, it is better than standard quicksort in both case. Also, when cutoff value is set to be smaller(3) or bigger(15), it's slower than when cutoff=7. So cutoff = 7 is the most suitable value here.

Q6.

Column2: Merge sort(Bottom-up), because every 4 elements has been sorted.

Column3: Quick sort(Standard, no shuffle), because we can observe that, before word "navy", all the element is "smaller" than navy, after "navy", all the element is bigger than "navy" (alphabetically). So the "navy" is the pivot here.

Column4:Kruth Shuffle: It seems keep implement Kruth Shuffle until word "silk".

Column5:Merge sort(top down), because the left half of the array has been sorted, and the each half of the last half of the array has been sorted. So it's merge sort. But here the number of the array's element is the power of 2, so it cannot be sure whether it is Bottom up or Top down. Considering we have already make sure the Column2 is Bottom up, so for here, it is top down version.

Column6: Insertion sort, because the invariants for insertion sort is: 1. Entries the left of index fixed and in ascending order. 2. Entries to the right of the index haven't been seen. Compare to column 8, we can assure column 6 is insertion sort, which up to "teal"

Column7: The current column is an max heap. So it is in an intermediate step of Heap Sort

Column8: Selection sort, because the invariants for selection sort is : 1. Entries the left of index fixed and in ascending order. 2. No entry to the right of index is smaller than any entry to the left of index. So it's selection sort up to "mint"

Column9:Quicksort(3-way,no shuffle),from the picture ,we can assure that the "navy" is the pivot here. We can tell the difference form the standard Quicksort by the place of the word"plum". For 3 way quick sort. "plum" is the first word to compare with the pivot "navy", since it is larger than "navy". So it exchange with the last word in the column, so "plum" is the last element in the column now.