DSA Homework 2 Report

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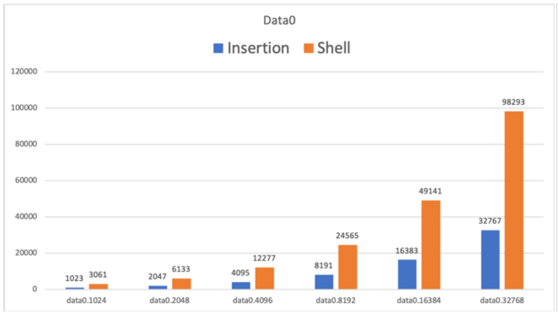
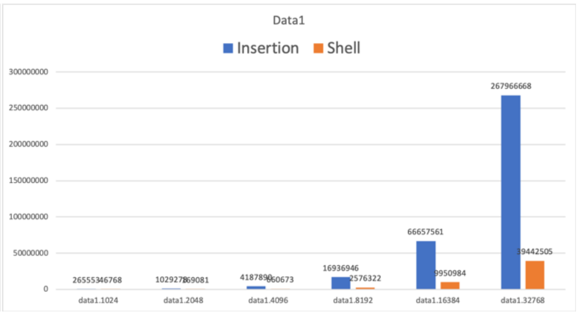
Question 1

File Name	Insertion	Shell	Runtime of Insertion	Runtime of Shell
data0.1024	1023	3061	0.000561237	0.000735998
data0.2048	2047	6133	0.000982046	0.001269102
data0.4096	4095	12277	0.002062082	0.002754688
data0.8192	8191	24565	0.004192114	0.004617929
data0.16384	16383	49141	0.007228851	0.009440184
data0.32768	32767	98293	0.016254902	0.018826962
data1.1024	265553	46768	0.072683096	0.01025176
data1.2048	1029278	169081	0.299160957	0.040673971
data1.4096	4187890	660673	1.303462029	0.183189869
data1.8192	16936946	2576322	4.897849083	0.603111029
data1.16384	66657561	9950984	19.38217998	2.316880941
data1.32768	267966668	39442505	78.57995605	9.297394037

As we can see from the figures and plots, when the data is sorted (data0.*), insertion sort is more effective. This makes sense because when the data is sorted, the insertion sort only takes (N-1) times of comparison while the shell sort need to compare (3*N-11) times of comparison.

However, when the data is shuffled, things are different. The shell, obviously, is much more effective than the insertion sort. Insertion sort works well on short sequences or partly sorted sequences, but shell sort first divides a long shuffled sequence into several short sequences and sort each part with insertion sort, which is more effective than using insertion sort all the way.



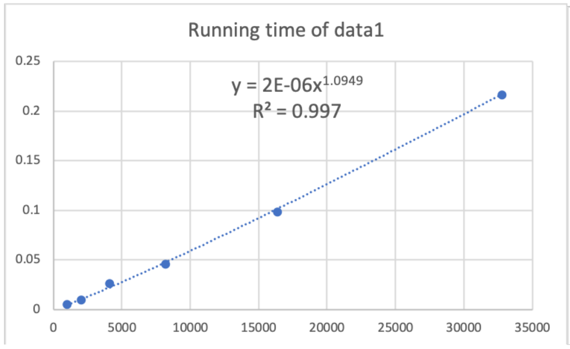


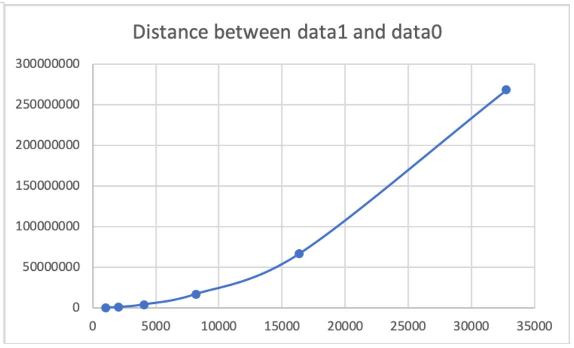
Question 2

File size (data1)	Running time	Distance
1024	0.004781723	264541
2048	0.009749889	1027236
4096	0.025924206	4183804

8192	0.045995951	16928767
16384	0.09845376	66641183
32768	0.216032982	267933908

After searching online on the definition of the Kendall Tau distance, I found that the Kendall Tau distance in this question is actually a sorting question, in which the distance is the number of comparisons. This is because the data0.* are all sorted. To calculate the distance effectively, I chose the merge sort algorithm and count the comparison times. As we can see from the plot, the O(N) of the runtime is almost linear. According to what we have learned from the course, the runtime cost should be O(N*logN).





Question 3

data0	comp in merge sort	comp in BUmer	runtime in merge sort	runtime in BUmer
1024	5120	5120	0.005332947	0.00449419
2048	11264	11264	0.00886488	0.007612944
4096	24576	24576	0.020756006	0.019711971
8192	53248	53248	0.040574312	0.035650015
16384	114688	114688	0.086947918	0.077246189
32768	245760	245760	0.19887805	0.177154779
data1	comp in merge sort	comp in BUmer	runtime in merge sort	runtime in BUmer
1024	8954	8954	0.004723072	0.004546881
2048	19934	19934	0.011224985	0.01044488
4096	43944	43944	0.045725822	0.038417816
8192	96074	96074	0.048655987	0.04848671
16384	208695	208695	0.097422123	0.105820894
32768	450132	450132	0.237993002	0.218292952

As we can see, the number of comparisons, no matter it is bottom-up merge sort or regular merge sort, is always the same for each dataset. This is because the data size is power of 2, so the comparison times are always the same. If the size is not power of 2, the situation will be different.

The runtime cost, however, differs a little bit. The bottom-up merge sort is faster than the regular merge sort because the bottom-up merge sort does not use recursion, which usually takes much time in the regular merge sort. The difference of runtime cost in this question is not obvious. I think if the data size is not power of 2, the difference will be clearer.

Question 4

In this question, I tried merge sort, insertion sort and bubble sort. All of them take O(N) runtime cost, but the bubble sort is the slowest. The merge sort is very quick and effective. The dataset is already sorted, so the merge sort basically just checks if the data is sorted recursively. The insertion sort is also effective. This is also because the data is sorted. It only takes (N-1) times of comparisons if we use insertion sort to sort this data.

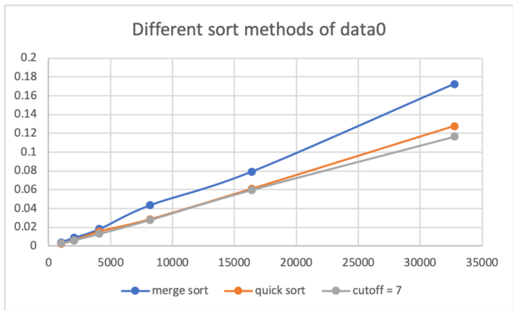
Question 5

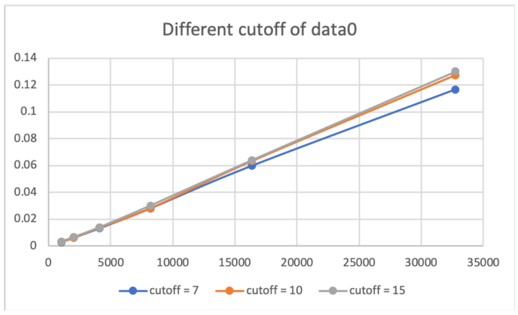
data0	merge sort	quick sort	cutoff = 7	cutoff = 10	cutoff = 15
1024	0.004071	0.00274611	0.00286198	0.00308084	0.00326514
2048	0.00863194	0.00610089	0.00616002	0.0061872	0.00662899
4096	0.01794934	0.01549697	0.01305509	0.01382279	0.01385593
8192	0.04331112	0.02855492	0.02789497	0.02806401	0.03001714
16384	0.07899594	0.06079388	0.05968618	0.06327868	0.06398082
32768	0.17245698	0.12750006	0.11651373	0.12713385	0.13007784
data1	merge sort	quick sort	cutoff = 7	cutoff = 10	cutoff = 15
1024	0.00521278	0.00335383	0.00294471	0.00310802	0.00327802
2048	0.00861716	0.007231	0.00661778	0.00690818	0.00715184
4096	0.0233109	0.01764297	0.015378	0.01549888	0.01656508
8192	0.0366292	0.03300571	0.03183627	0.03272414	0.03293109
16384	0.09173727	0.07215309	0.06971598	0.07360077	0.07505202
32768	0.20467806	0.14385796	0.14204168	0.14216709	0.14427805

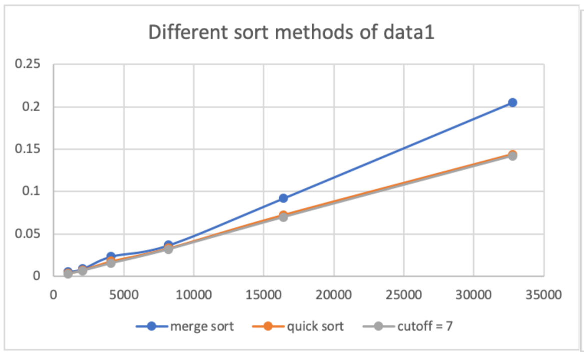
In this question, I compared the performance, which is the runtime cost, among merge sort, quick sort and quick sort with cut-off. There is no doubt that the quick sort, with or without cut-off, is faster than the merge sort. This is because the merge sort uses recursive method, which takes much time when running the algorithm.

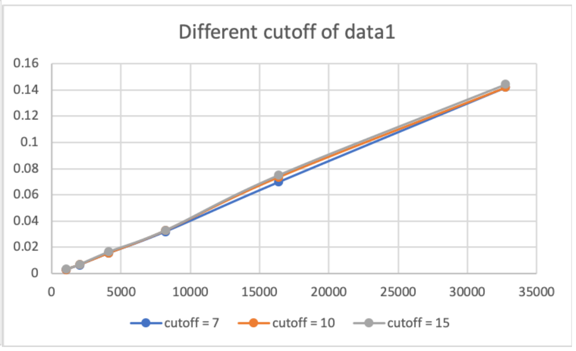
When comparing the performance between the quick sort and the quick sort with cut-off, I found that when the data is a sorted short sequence, quick sort is faster than quick sort with cut-off. As the data grows larger, quick sort with cut-off becomes better than quick sort. When the data is shuffled, quick sort with cut-off is also faster.

As for the number of cut-off, I get the result from the figure that in this question, the cut-off in the range from 7 to 10 is a good choice. Even if some of them are slower than quick sort, the difference is very small. For the cut-off that is larger than 10, the runtime cost is obviously larger, especially in the small dataset.









Question 6

Col.2: Mergesort (bottom-up). Every four elements are sorted.

Col.3: Quicksort (standard, no shuffle). Every element before “navy” is smaller than it while every element after is bigger.

Col.4: Knuth shuffle. All the elements before “silk” is shuffled and the other are in place.

Col.5: Mergesort (top-down). The first half of the column is sorted and both halves of the last half of the column are sorted respectively.

Col.6: Insertion sort. All the elements before “teal” are sorted, but they are different from the last column and other elements remain in place.

Col.7: Heap sort. This column looks like a max heap, so I think it is a heap sort.

Col.8: Selection sort. All the elements before “mint” are sorted and are the same of the last column while other elements remain in place.

Col.9: Quicksort (3-way, no-shuffle). Every element before “navy” is smaller than it while every element after is bigger. The last one is “plum”, which is first element that is bigger than “navy”. In the quick sort with 3-way, it is exchanged with the arr[hi] and get decrement.