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COT 4400: Design and Analysis of Algorithms
Professor: Dr. Mihaela Cardei
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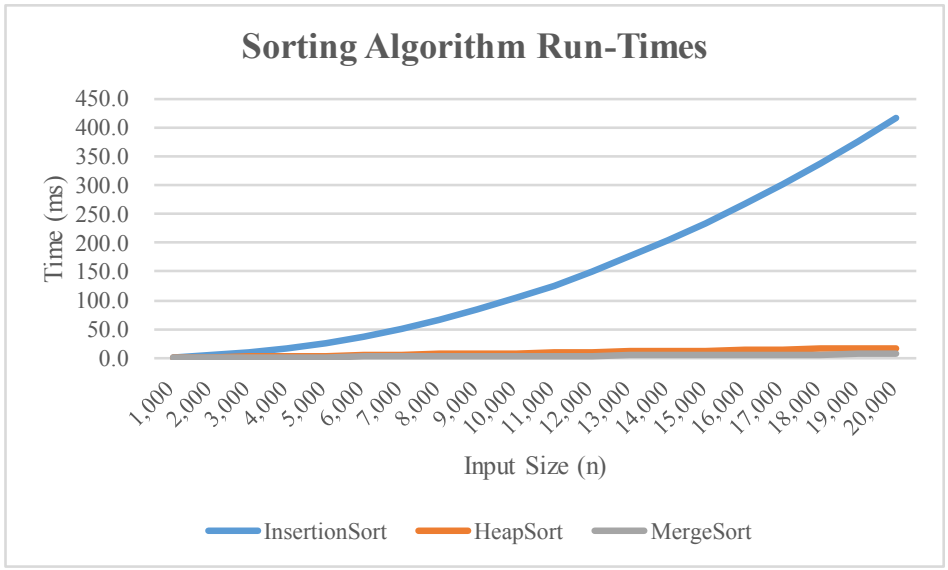
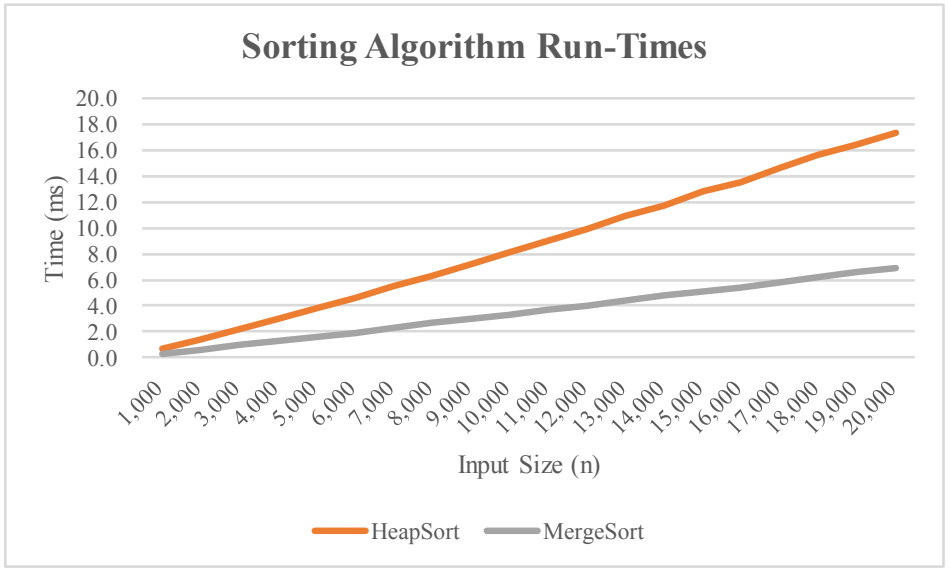
Programming Assignment 3

The graphs below show the run-time in milliseconds over a range of input sizes from 1,000 to 20,000. Note that the for each input size, n, the time is calculated as the average run-time for 10 separate executions of each algorithm.

The graph below on the left below shows the run-times for InsertionSort, HeapSort and MergeSort. The graph below on the right shows the run-times for HeapSort and MergeSort only. Because the worst-case run-time of InsertionSort is $O(n^2)$ and the worst-case run-time of HeapSort and MergeSort is O(n lg n), the run-time for InsertionSort grows at a much faster rate than it does for HeapSort and MergeSort as the input size, n, increases. The growth of HeapSort and MergeSort cannot be seen clearly on the same scale as InsertionSort, so I included an additional graph showing just HeapSort and MergeSort.





The tables below show a comparison of the actual and theoretical run-times for each algorithm. O-notation gives an upper bound on a function to within a constant factor. Such constant factors can be calculated for the three sorting algorithms by dividing the simulated run-time by the theoretical run-time. Since O-notation gives an upper bound, the maximum hidden constant is calculated over all input sizes. For InsertionSort, the maximum hidden constant is 1.1. For HeapSort, the maximum hidden constant is 64.6. For MergeSort, the maximum hidden constant is 32.1.

InsertionSort Run-Time (RT)

n	Theoretical RT $O(n^2)$	Simulated RT (ms)	Hiddent Constant
1,000	1×10^6	1.1	1.1
2,000	4×10^6	4.3	1.1
3,000	9×10^6	9.6	1.1
4,000	16×10^6	16.8	1.1
5,000	25×10^6	26.3	1.1
6,000	36×10^6	37.6	1.0
7,000	49×10^6	51.0	1.0
8,000	64×10^6	66.6	1.0
9,000	81×10^6	84.8	1.0
10,000	100×10^6	103.9	1.0
11,000	121×10^6	125.9	1.0
12,000	144×10^6	149.8	1.0
13,000	169×10^6	176.3	1.0
14,000	196×10^6	203.7	1.0
15,000	225×10^6	234.1	1.0
16,000	256×10^6	266.3	1.0
17,000	289×10^6	300.8	1.0
18,000	324×10^6	336.9	1.0
19,000	361×10^6	375.1	1.0
20,000	400×10^6	416.4	1.0
Maximum Hidden Constant Value			**1.1**

HeapSort Run-Time (RT)

n	Theoretical RT O(n lg n)	Simulated RT (ms)	Hiddent Constant
1,000	10×10^3	0.6	64.6
2,000	22×10^3	1.4	63.4
3,000	35×10^3	2.2	62.9
4,000	48×10^3	3.0	61.8
5,000	61×10^3	3.8	61.8
6,000	75×10^3	4.6	61.1
7,000	89×10^3	5.5	61.4
8,000	104×10^3	6.3	61.1
9,000	118×10^3	7.2	60.9
10,000	133×10^3	8.2	61.4
11,000	148×10^3	9.0	60.9
12,000	163×10^3	9.9	60.9
13,000	178×10^3	10.9	61.3
14,000	193×10^3	11.7	60.7
15,000	208×10^3	12.8	61.6
16,000	223×10^3	13.5	60.5
17,000	239×10^3	14.6	61.1
18,000	254×10^3	15.6	61.3
19,000	270×10^3	16.5	61.1
20,000	286×10^3	17.4	60.8
Maximum Hidden Constant Value			**64.6**

MergeSort Run-Time (RT)

n	Theoretical RT O(n lg n)	Simulated RT (ms)	Hiddent Constant
1,000	10×10^3	0.3	32.1
2,000	22×10^3	0.6	28.5
3,000	35×10^3	0.9	27.4
4,000	48×10^3	1.3	27.2
5,000	61×10^3	1.6	26.6
6,000	75×10^3	1.9	25.6
7,000	89×10^3	2.3	26.0
8,000	104×10^3	2.7	25.6
9,000	118×10^3	3.0	25.2
10,000	133×10^3	3.3	25.2
11,000	148×10^3	3.7	25.1
12,000	163×10^3	4.0	24.9
13,000	178×10^3	4.4	24.7
14,000	193×10^3	4.8	25.1
15,000	208×10^3	5.1	24.6
16,000	223×10^3	5.4	24.3
17,000	239×10^3	5.8	24.5
18,000	254×10^3	6.2	24.4
19,000	270×10^3	6.6	24.5
20,000	286×10^3	6.9	24.2
Maximum Hidden Constant Value			**32.1**