Homework 1 Report

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聲明：此作業之所有數據與程式代碼均為我本人所寫，絕無任何抄襲之情形。

簡介

此篇作業由不同大小的數據集驗證 Insertion Sort、Merge Sort、Heap Sort 及 Quick Sort 四種排序演算法在 Best Case、Worst Case 及 Average Case 下的表現。

數據分析

由圖（一）可以發現在 Best Case 情況下，Insertion Sort 的表現是最好的、Quick Sort 的表現是最差的，而 Merge Sort 及 Heap Sort 的表現差不多比 Quick Sort 好一點，而由表（一）、（二）可以得知，Merge Sort 及 Heap Sort 的斜率約為 1、Quick Sort 約為 1.6，而 Insertion Sort 的斜率僅約 0.5，這是因為在 Best Case 的情況下讀取的時間就比他排序的時間還多了，所以才會有斜率低於 1 很多的情況，這驗證了 Insertion Sort 在 Best Case 的情況下時間複雜度為 $O(n)$，而 Quick Sort、Merge Sort 及 Heap Sort 的時間複雜度均為 $O(n\log n)$。

由圖（二）可以發現在 Worst Case 情況下，Insertion Sort 及 Quick Sort 的表現是最差的，而 Merge Sort 及 Heap Sort 的表現較好，而由表（一）、（二）可以得知，Merge Sort 及 Heap Sort 的斜率約為 1、Quick Sort 約為 2，而 Insertion Sort 的斜率約 1.6，這驗證了 Insertion Sort 及 Quick Sort 在 Worst Case 的情況下時間複雜度為 $O(n^2)$，而 Merge Sort 及 Heap Sort 的時間複雜度均為 $O(n\log n)$。

由圖（三）可以發現在 Average Case 情況下，Insertion Sort 的表現是最差的，而 Merge Sort、Heap Sort 及 Quick Sort 的表現較好，而由表（一）、（二）可以得知，Merge Sort 、Heap Sort 及 Quick Sort 的斜率約為 1，而 Insertion Sort 的斜率約 2，這驗證了 Insertion Sort 在 Average Case 的情況下時間複雜度為 $O(n^2)$，而 Merge Sort、Heap Sort 及 Quick Sort 的時間複雜度均為 $O(n\log n)$。
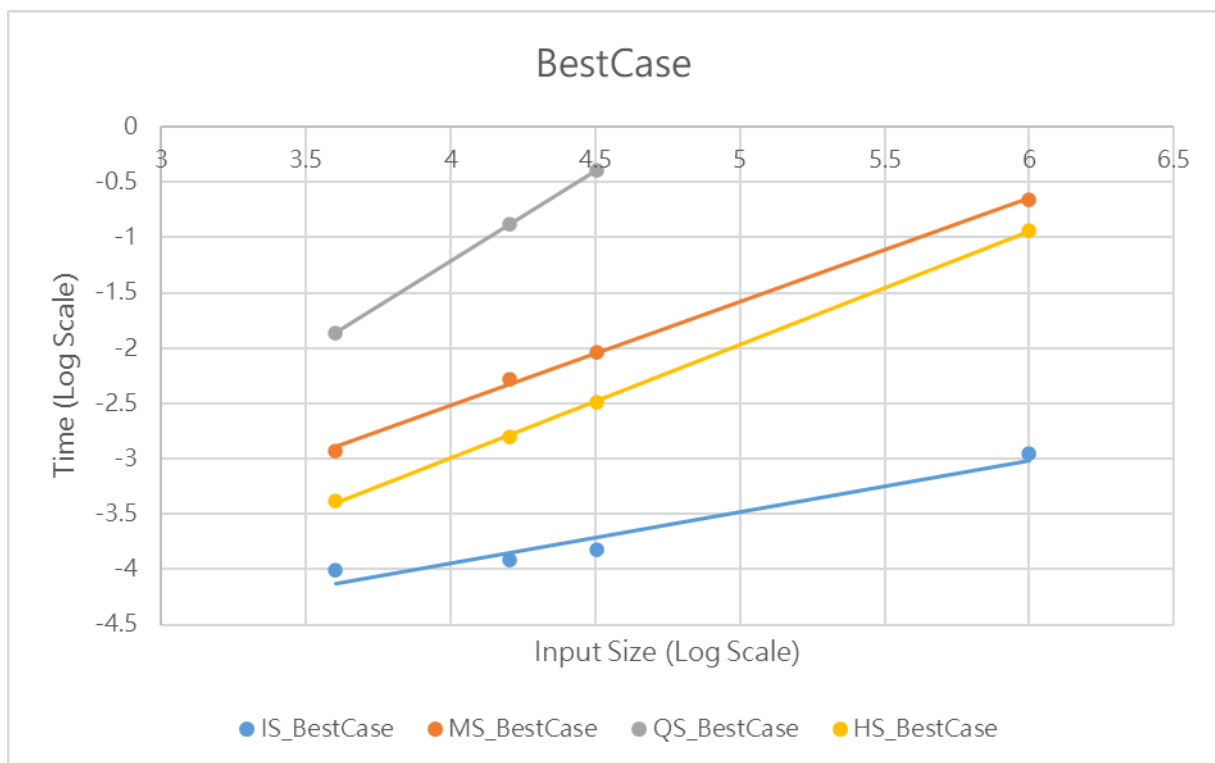
圖表

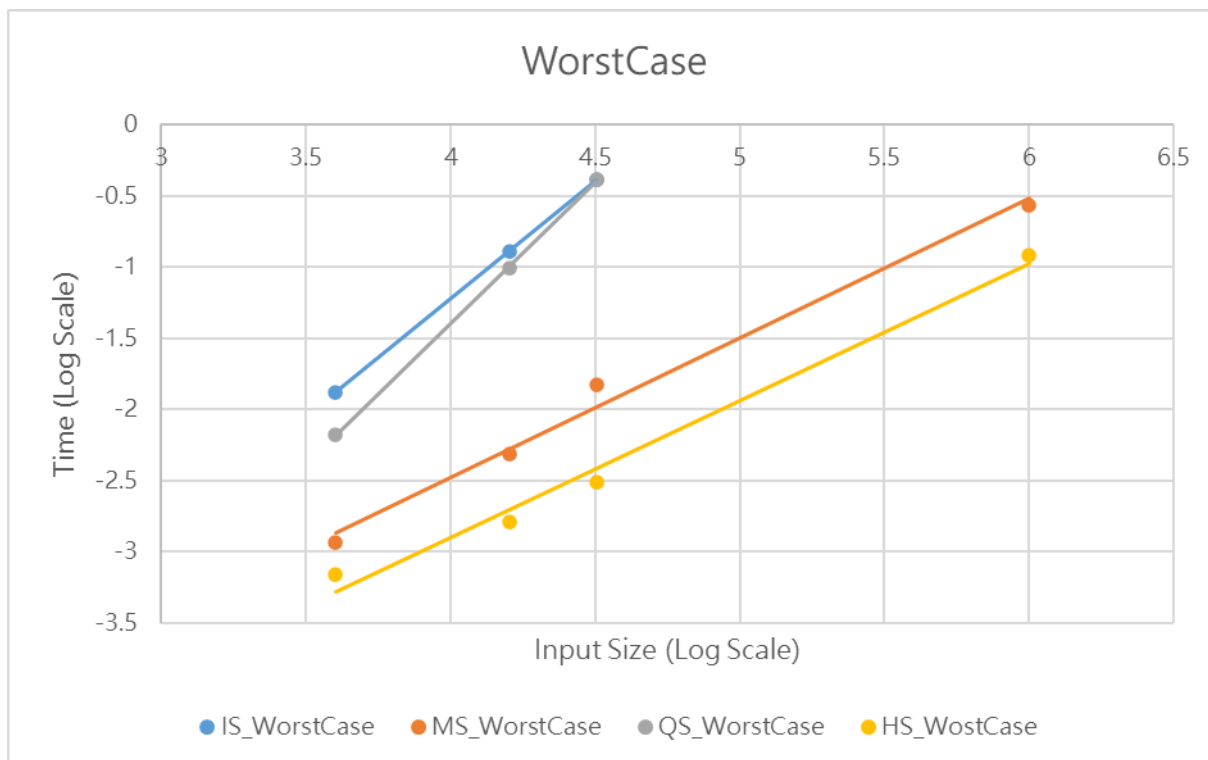表（一）四種排序法在測試不同數據集之時間表現與記憶體表現，其中 IS 為 Insertion Sort、MS 為 Merge Sort、QS 為 Quick Sort、HS 為 Heap Sort。

Input size	IS		MS		QS		HS	
	CPU time(s)	Memory(KB)	CPU time(s)	Memory(KB)	CPU time(s)	Memory(KB)	CPU time(s)	Memory(KB)
4000.case2	0.000099	6052	0.001167	6060	0.013641	6052	0.000418	6052
4000.case3	0.013224	6052	0.001160	6060	0.006716	6052	0.000695	6052
4000.case1	0.004341	6052	0.002165	6060	0.000365	6052	0.000573	6052
16000.case2	0.000122	6076	0.005301	6076	0.132278	6076	0.001590	6076
16000.case3	0.130660	6076	0.004840	6076	0.097948	6076	0.001616	6076
16000.case1	0.062671	6076	0.009739	6076	0.002399	6076	0.002393	6076
32000.case2	0.000149	6208	0.009065	6336	0.403454	6208	0.003200	6208
32000.case3	0.410118	6208	0.015040	6336	0.411929	6208	0.003126	6208
32000.case1	0.250907	6208	0.017800	6336	0.004938	6208	0.004823	6208
1000000.case2	0.001101	12164	0.221159	16256	224.2510	12164	0.115482	12164
1000000.case3	374.7420	12164	0.274191	16256	255.4120	14340	0.120815	12164
1000000.case1	187.4670	12164	0.346516	16256	112.996	12164	0.160200	12164

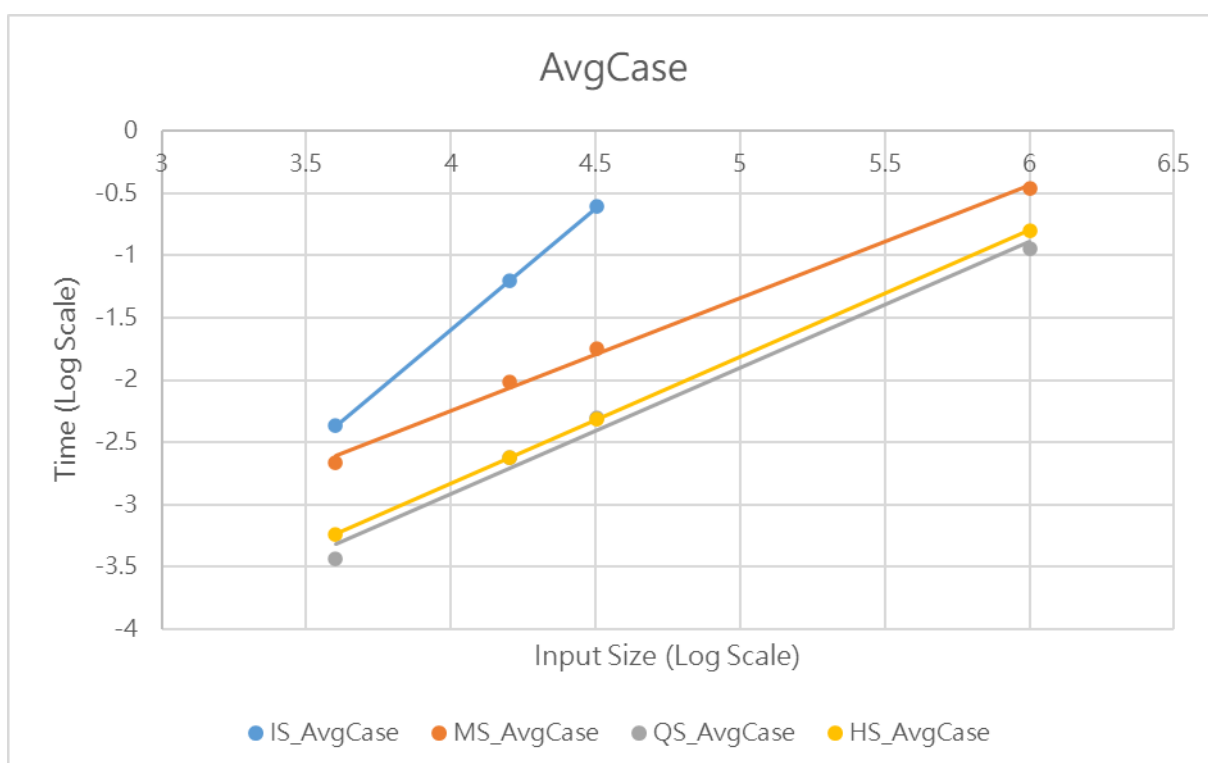表（二）不同情形下各種排序演算法的斜率，其中 x 軸為 Input Size (Log Scale)，y 軸為 Time (Log Scale)。

	AvgCase	BestCase	WorstCase
	slope		
IS	1.9474	0.4619	1.6517
MS	0.9053	0.9388	0.9818
QS	1.0112	1.6302	1.9729
HS	1.0194	1.0228	0.9621

圖（一）在 Best Case 情況下，四種排序法所需時間的比較圖。

圖（二）在 Worst Case 情況下，四種排序法所需時間的比較圖。

圖（三）在 Average Case 情況下，四種排序法所需時間的比較圖。

附錄

以下為跑數據時 terminal 所顯示之畫面

```
b09502138@linux1 [~/EE/PA1] ./bin/NTU_sort -HS inputs/1000000.case1.in outputs/1000000.case1.out
The total CPU time: 160.2ms
memory: 12164KB
b09502138@linux1 [~/EE/PA1] ./bin/NTU_sort -HS inputs/1000000.case2.in outputs/1000000.case2.out
The total CPU time: 115.482ms
memory: 12164KB
b09502138@linux1 [~/EE/PA1] ./bin/NTU_sort -HS inputs/1000000.case3.in outputs/1000000.case3.out
The total CPU time: 120.815ms
memory: 12164KB
b09502138@linux1 [~/EE/PA1] ./bin/NTU_sort -HS inputs/32000.case3.in outputs/32000.case3.out
The total CPU time: 3.126ms
memory: 6208KB
b09502138@linux1 [~/EE/PA1] ./bin/NTU_sort -HS inputs/32000.case2.in outputs/32000.case2.out
The total CPU time: 3.2ms
memory: 6208KB
b09502138@linux1 [~/EE/PA1] ./bin/NTU_sort -HS inputs/32000.case1.in outputs/32000.case1.out
The total CPU time: 4.823ms
memory: 6208KB
b09502138@linux1 [~/EE/PA1] ./bin/NTU_sort -HS inputs/16000.case1.in outputs/16000.case1.out
The total CPU time: 2.393ms
memory: 6076KB
b09502138@linux1 [~/EE/PA1] ./bin/NTU_sort -HS inputs/16000.case2.in outputs/16000.case2.out
The total CPU time: 1.59ms
memory: 6076KB
b09502138@linux1 [~/EE/PA1] ./bin/NTU_sort -HS inputs/16000.case3.in outputs/16000.case3.out
The total CPU time: 1.616ms
memory: 6076KB
b09502138@linux1 [~/EE/PA1] ./bin/NTU_sort -HS inputs/4000.case3.in outputs/4000.case3.out
The total CPU time: 0.695ms
memory: 6052KB
b09502138@linux1 [~/EE/PA1] ./bin/NTU_sort -HS inputs/4000.case2.in outputs/4000.case2.out
The total CPU time: 0.418ms
memory: 6052KB
b09502138@linux1 [~/EE/PA1] ./bin/NTU_sort -HS inputs/4000.case1.in outputs/4000.case1.out
The total CPU time: 0.573ms
memory: 6052KB
```

```
b09502138@linux1 [~/EE/PA1] ./bin/NTU_sort -IS inputs/4000.case1.in outputs/4000.case1.out
The total CPU time: 4.341ms
memory: 6052KB
b09502138@linux1 [~/EE/PA1] ./bin/NTU_sort -IS inputs/4000.case2.in outputs/4000.case2.out
The total CPU time: 0.099ms
memory: 6052KB
b09502138@linux1 [~/EE/PA1] ./bin/NTU_sort -IS inputs/4000.case3.in outputs/4000.case3.out
The total CPU time: 13.224ms
memory: 6052KB
b09502138@linux1 [~/EE/PA1] ./bin/NTU_sort -IS inputs/16000.case3.in outputs/16000.case3.out
The total CPU time: 130.66ms
memory: 6076KB
b09502138@linux1 [~/EE/PA1] ./bin/NTU_sort -IS inputs/16000.case2.in outputs/16000.case2.out
The total CPU time: 0.122ms
memory: 6076KB
b09502138@linux1 [~/EE/PA1] ./bin/NTU_sort -IS inputs/16000.case1.in outputs/16000.case1.out
The total CPU time: 62.671ms
memory: 6076KB
b09502138@linux1 [~/EE/PA1] ./bin/NTU_sort -IS inputs/32000.case1.in outputs/32000.case1.out
The total CPU time: 250.907ms
memory: 6208KB
b09502138@linux1 [~/EE/PA1] ./bin/NTU_sort -IS inputs/32000.case2.in outputs/32000.case2.out
The total CPU time: 0.149ms
memory: 6208KB
b09502138@linux1 [~/EE/PA1] ./bin/NTU_sort -IS inputs/32000.case3.in outputs/32000.case3.out
The total CPU time: 410.118ms
memory: 6208KB
b09502138@linux1 [~/EE/PA1] ./bin/NTU_sort -IS inputs/1000000.case3.in outputs/1000000.case3.out
The total CPU time: 374742ms
memory: 12164KB
b09502138@linux1 [~/EE/PA1] ./bin/NTU_sort -IS inputs/1000000.case2.in outputs/1000000.case2.out
The total CPU time: 1.101ms
memory: 12164KB
^[[Ab09502138@linux1 [~/EE/PA1] ./bin/NTU_sort -IS inputs/1000000.case1.in outputs/1000000.case1.out
The total CPU time: 187467ms
memory: 12164KB
```

```
b09502138@linux1 [~/EE/PA1] ./bin/NTU_sort -MS inputs/4000.case1.in outputs/4000.case1.out
The total CPU time: 2.165ms
memory: 6060KB
b09502138@linux1 [~/EE/PA1] ./bin/NTU_sort -MS inputs/4000.case2.in outputs/4000.case2.out
The total CPU time: 1.167ms
memory: 6060KB
b09502138@linux1 [~/EE/PA1] ./bin/NTU_sort -MS inputs/4000.case3.in outputs/4000.case3.out
The total CPU time: 1.16ms
memory: 6060KB
b09502138@linux1 [~/EE/PA1] ./bin/NTU_sort -MS inputs/16000.case3.in outputs/16000.case3.out
The total CPU time: 4.84ms
memory: 6076KB
b09502138@linux1 [~/EE/PA1] ./bin/NTU_sort -MS inputs/16000.case2.in outputs/16000.case2.out
The total CPU time: 5.301ms
memory: 6076KB
b09502138@linux1 [~/EE/PA1] ./bin/NTU_sort -MS inputs/16000.case1.in outputs/16000.case1.out
The total CPU time: 9.739ms
memory: 6076KB
b09502138@linux1 [~/EE/PA1] ./bin/NTU_sort -MS inputs/32000.case1.in outputs/32000.case1.out
The total CPU time: 17.8ms
memory: 6336KB
b09502138@linux1 [~/EE/PA1] ./bin/NTU_sort -MS inputs/32000.case2.in outputs/32000.case2.out
The total CPU time: 9.065ms
memory: 6336KB
b09502138@linux1 [~/EE/PA1] ./bin/NTU_sort -MS inputs/32000.case3.in outputs/32000.case3.out
The total CPU time: 15.041ms
memory: 6336KB
b09502138@linux1 [~/EE/PA1] ./bin/NTU_sort -MS inputs/1000000.case3.in outputs/1000000.case3.out
The total CPU time: 274.191ms
memory: 16256KB
b09502138@linux1 [~/EE/PA1] ./bin/NTU_sort -MS inputs/1000000.case2.in outputs/1000000.case2.out
The total CPU time: 221.159ms
memory: 16256KB
b09502138@linux1 [~/EE/PA1] ./bin/NTU_sort -MS inputs/1000000.case1.in outputs/1000000.case1.out
The total CPU time: 346.516ms
memory: 16256KB
```

```
b09502138@linux1 [~/EE/PA1] ./bin/NTU_sort -QS inputs/1000000.case1.in outputs/1000000.case1.out
The total CPU time: 112.996ms
memory: 12164KB
b09502138@linux1 [~/EE/PA1] ./bin/NTU_sort -QS inputs/1000000.case2.in outputs/1000000.case2.out
The total CPU time: 224251ms
memory: 12164KB
b09502138@linux1 [~/EE/PA1] ./bin/NTU_sort -QS inputs/1000000.case3.in outputs/1000000.case3.out
The total CPU time: 255412ms
memory: 14340KB
```

```
b09502138@linux1 [~/EE/PA1] ./bin/NTU_sort -QS inputs/32000.case3.in outputs/32000.case3.out
The total CPU time: 411.929ms
memory: 6208KB
b09502138@linux1 [~/EE/PA1] ./bin/NTU_sort -QS inputs/32000.case2.in outputs/32000.case2.out
The total CPU time: 403.454ms
memory: 6208KB
b09502138@linux1 [~/EE/PA1] ./bin/NTU_sort -QS inputs/32000.case1.in outputs/32000.case1.out
The total CPU time: 4.938ms
memory: 6208KB
```

```
b09502138@linux1 [~/EE/PA1] ./bin/NTU_sort -QS inputs/16000.case1.in outputs/16000.case1.out
The total CPU time: 2.399ms
memory: 6076KB
b09502138@linux1 [~/EE/PA1] ./bin/NTU_sort -QS inputs/16000.case2.in outputs/16000.case2.out
The total CPU time: 132.278ms
memory: 6076KB
b09502138@linux1 [~/EE/PA1] ./bin/NTU_sort -QS inputs/16000.case3.in outputs/16000.case3.out
The total CPU time: 97.948ms
memory: 6076KB
b09502138@linux1 [~/EE/PA1] ./bin/NTU_sort -QS inputs/4000.case3.in outputs/4000.case3.out
The total CPU time: 6.716ms
memory: 6052KB
b09502138@linux1 [~/EE/PA1] ./bin/NTU_sort -QS inputs/4000.case2.in outputs/4000.case2.out
The total CPU time: 13.641ms
memory: 6052KB
b09502138@linux1 [~/EE/PA1] ./bin/NTU_sort -QS inputs/4000.case1.in outputs/4000.case1.out
The total CPU time: 0.365ms
memory: 6052KB
```