**2022 NYCU OS HW2 report**

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| Question | Answer |
| Q1. (5pts)  Briefly describe your design for the add, multiple function of matrix, the thread management.  Also, describe the number of threads in the Multi-thread program. | 將複雜度最高的矩陣乘法O(n^3) 以最外層的迴圈分成n 份， main 先開 n-1 個thread 處理前n-1 份，main 再處理最後一份及矩陣加法、輸出加法答案，再 thread join ，最後輸出乘法答案。在自己電腦跑時，基本上thread 越多越快，然而在工作站則是 4 個 thread 最好。 lscpu 可以得知工作站 CPU 最多支援 4 個 thread ，再多硬體不支援，實際上也不是平行運算，還要增加切換所耗費時間。 |
| Q2. (15pts)  Try at least 3 kinds of number of threads, and compare the difference in time.(Take screenshots of the time of each case)  Also, explain the results. | 上圖分別為 2、10、20 個thread 在本機的結果，基本上越多thread 效率越好，但變好的幅度降低，下方附有更詳盡的結果，當thread 數量碰上硬體限制也就不降反升，且 thread 到一定數量能增加的 速率便不划算。 |
| Q3. (10pts)  Show the best speedup between multi-thread and single-thread. (Take screenshots of the time of single-thread and multi-thread)  Also, explain why multi-thread is faster. | Speedup: 0.511 / 0.110 = 4.645  在硬體支援的情況下 multi thread 可以同時運作，即可以平行進行運算，自然可以比 Sigle thread 更快算出結果。 |

Script 執行 Single thread 與 2~20 個的 Multi thread 結果：

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| 本機 | 工作站 |
| Single thread:  real 0m0.506s  user 0m0.478s  sys 0m0.000s  Multi thread:  -------------------------------------  Thread number: 2  real 0m0.257s  user 0m0.439s  sys 0m0.000s  -------------------------------------  Thread number: 3  real 0m0.202s  user 0m0.483s  sys 0m0.000s  -------------------------------------  Thread number: 4  real 0m0.158s  user 0m0.462s  sys 0m0.000s  -------------------------------------  Thread number: 5  real 0m0.149s  user 0m0.489s  sys 0m0.000s  -------------------------------------  Thread number: 6  real 0m0.165s  user 0m0.634s  sys 0m0.000s  -------------------------------------  Thread number: 7  real 0m0.138s  user 0m0.576s  sys 0m0.000s  -------------------------------------  Thread number: 8  real 0m0.135s  user 0m0.600s  sys 0m0.018s  -------------------------------------  Thread number: 9  real 0m0.121s  user 0m0.622s  sys 0m0.000s  -------------------------------------  Thread number: 10  real 0m0.110s  user 0m0.662s  sys 0m0.000s  -------------------------------------  Thread number: 11  real 0m0.116s  user 0m0.730s  sys 0m0.000s  -------------------------------------  Thread number: 12  real 0m0.112s  user 0m0.781s  sys 0m0.000s  -------------------------------------  Thread number: 13  real 0m0.116s  user 0m0.733s  sys 0m0.010s  -------------------------------------  Thread number: 14  real 0m0.126s  user 0m0.792s  sys 0m0.000s  -------------------------------------  Thread number: 15  real 0m0.123s  user 0m0.718s  sys 0m0.009s  -------------------------------------  Thread number: 16  real 0m0.124s  user 0m0.770s  sys 0m0.000s  -------------------------------------  Thread number: 17  real 0m0.124s  user 0m0.753s  sys 0m0.009s  -------------------------------------  Thread number: 18  real 0m0.121s  user 0m0.752s  sys 0m0.000s  -------------------------------------  Thread number: 19  real 0m0.123s  user 0m0.812s  sys 0m0.009s  -------------------------------------  Thread number: 20  real 0m0.117s  user 0m0.821s  sys 0m0.000s | Single thread:  real 0m0.979s  user 0m0.712s  sys 0m0.004s  Multi thread:  -------------------------------------  Thread number: 2  real 0m0.632s  user 0m0.582s  sys 0m0.008s  -------------------------------------  Thread number: 3  real 0m0.285s  user 0m0.649s  sys 0m0.008s  -------------------------------------  Thread number: 4  real 0m0.213s  user 0m0.615s  sys 0m0.006s  -------------------------------------  Thread number: 5  real 0m0.400s  user 0m0.603s  sys 0m0.006s  -------------------------------------  Thread number: 6  real 0m0.362s  user 0m0.597s  sys 0m0.005s  -------------------------------------  Thread number: 7  real 0m0.187s  user 0m0.571s  sys 0m0.014s  -------------------------------------  Thread number: 8  real 0m0.328s  user 0m0.579s  sys 0m0.006s  -------------------------------------  Thread number: 9  real 0m0.267s  user 0m0.574s  sys 0m0.009s  -------------------------------------  Thread number: 10  real 0m0.308s  user 0m0.580s  sys 0m0.007s  -------------------------------------  Thread number: 11  real 0m0.362s  user 0m0.578s  sys 0m0.005s  -------------------------------------  Thread number: 12  real 0m0.205s  user 0m0.586s  sys 0m0.007s  -------------------------------------  Thread number: 13  real 0m0.185s  user 0m0.580s  sys 0m0.006s  -------------------------------------  Thread number: 14  real 0m0.190s  user 0m0.577s  sys 0m0.007s  -------------------------------------  Thread number: 15  real 0m0.334s  user 0m0.576s  sys 0m0.005s  -------------------------------------  Thread number: 16  real 0m0.191s  user 0m0.568s  sys 0m0.010s  -------------------------------------  Thread number: 17  real 0m0.207s  user 0m0.594s  sys 0m0.005s  -------------------------------------  Thread number: 18  real 0m0.315s  user 0m0.572s  sys 0m0.011s  -------------------------------------  Thread number: 19  real 0m0.218s  user 0m0.589s  sys 0m0.004s  -------------------------------------  Thread number: 20  real 0m0.345s  user 0m0.594s  sys 0m0.007s |