# AMATH 583: HW 2

Minho Choi

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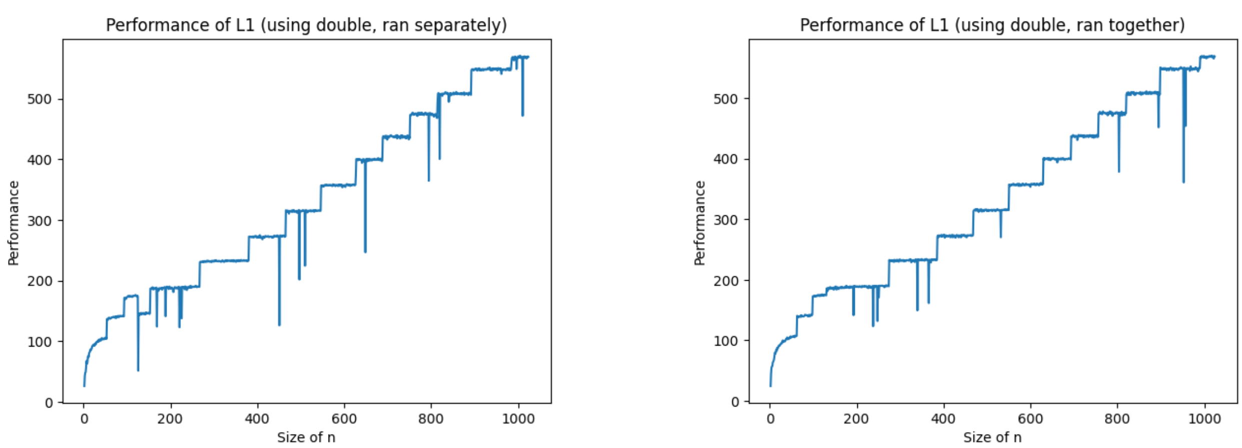
## Problem 1

For Level 1 BLAS using daxpy function, we get:



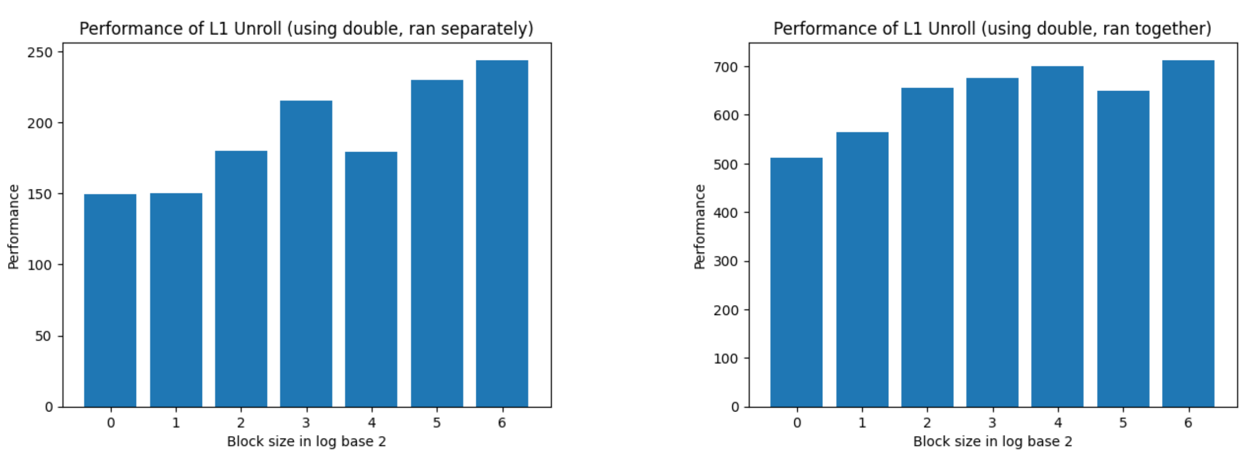

(a) Ran separately (b) Ran together

Figure 1: Performance of Level 1 BLAS using double

Note that these two graphs have the least difference between the two, since daxpy function was ran the first. If the daxpy function was ran latter, for instance after axpy function, I believe the graph (b) will look like the graph (b) in Figure 3. I think there is some kind of optimization performed by the compiler, if similar process is repeated then the program performs faster and faster as it proceed. However, this is just a guess. I am not exactly sure why this happens.

## Problem 2

For Level 1 Unroll BLAS using daxpy_unroll function, we get:



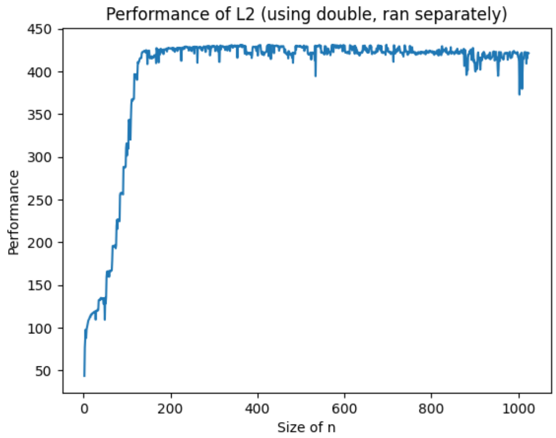

(a) Ran separately (b) Ran together

Figure 2: Performance of Level 1 Unroll BLAS using double

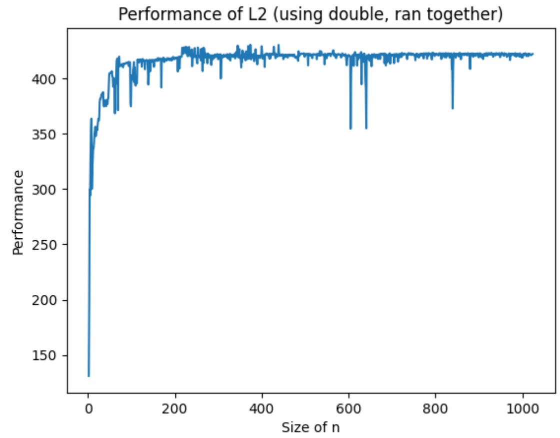
Here, it is important to note that the performance values range from 150 to 250 when ran separately, while the performance values range from 500 to 720 when ran together.

# Problem 3

For Level 2 BLAS using dgemv function, we get:




(a) Ran separately

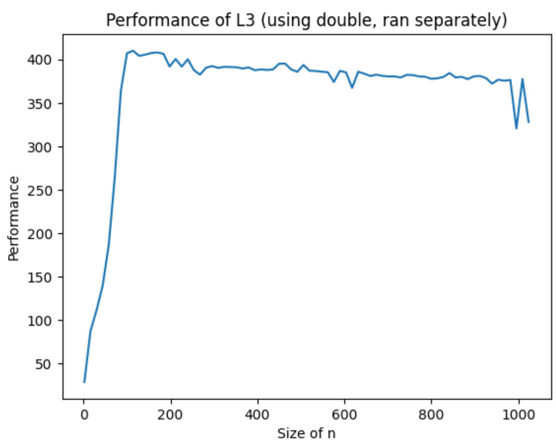



(b) Ran together

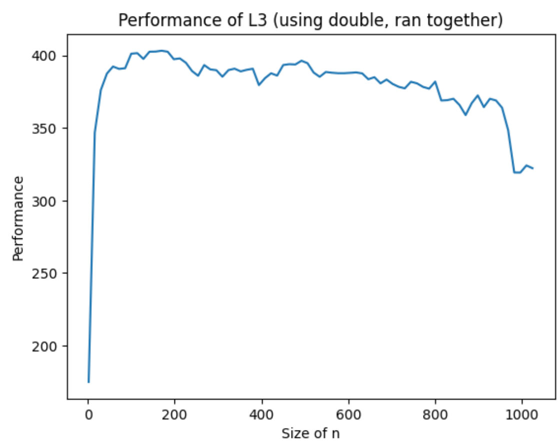
Figure 3: Performance of Level 2 BLAS using double

# Problem 4

For Level 3 BLAS using dgemm function, we get:




(a) Ran separately

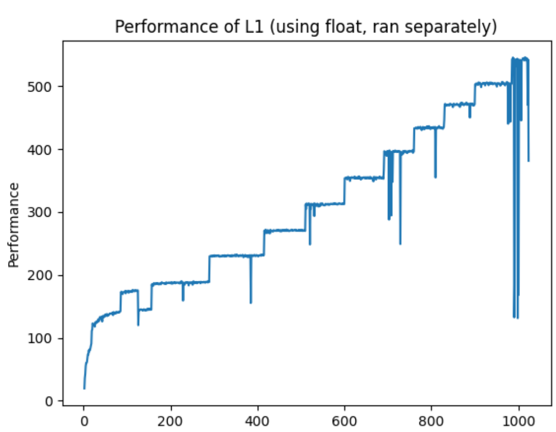



(b) Ran together

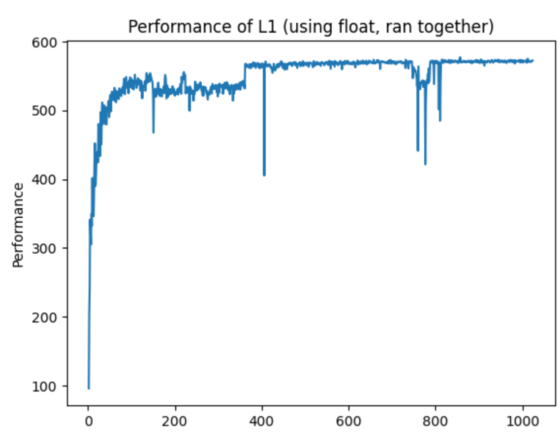
Figure 4: Performance of Level 3 BLAS using double

# Problem 5

For Level 1 BLAS using axpy function, we get:



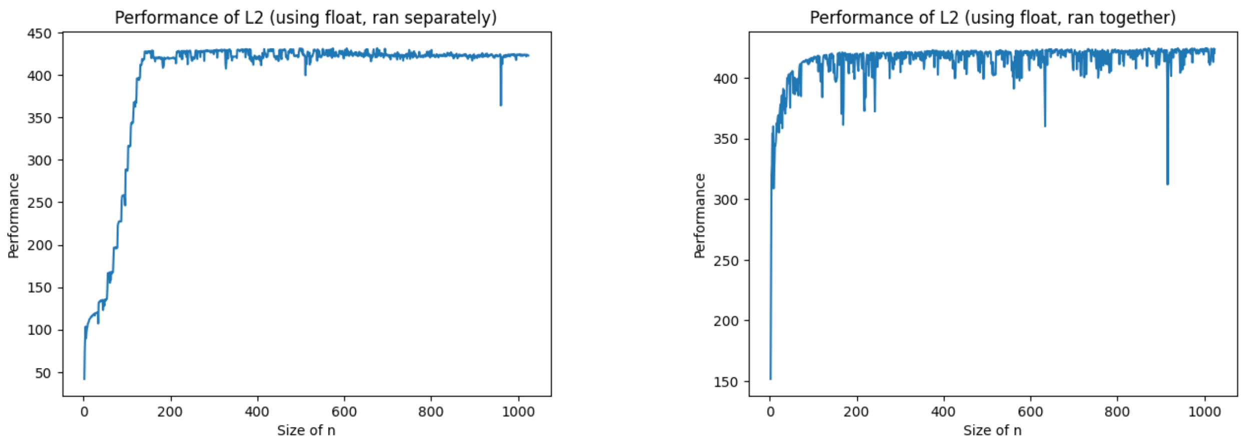

(a) Ran separately




(b) Ran together

Figure 5: Performance of Level 1 BLAS using float

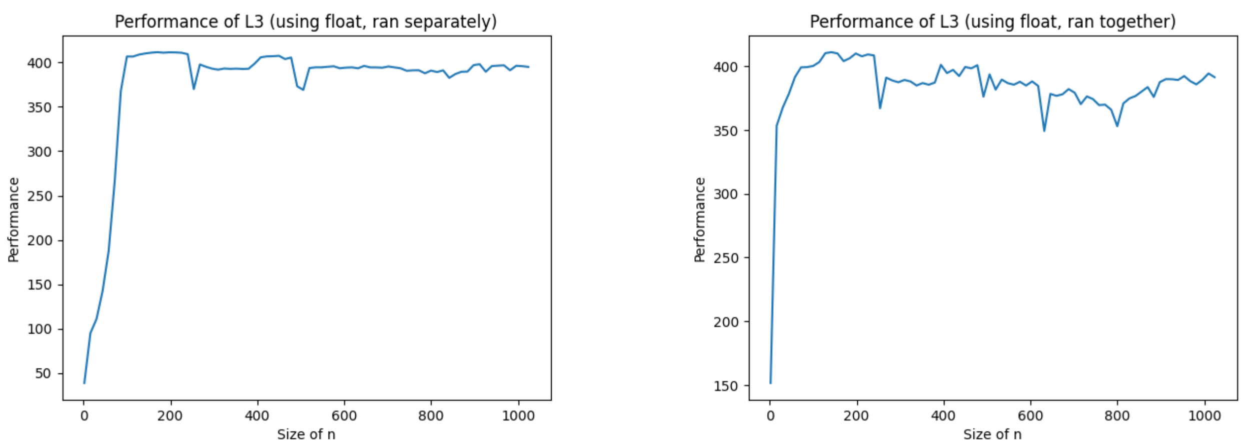
For Level 2 BLAS using gemv function, we get:




(a) Ran separately (b) Ran together

Figure 6: Performance of Level 2 BLAS using float

For Level 3 BLAS using gemm function, we get:




(a) Ran separately (b) Ran together

Figure 7: Performance of Level 3 BLAS using float

# Extra Credit

**(1)** First the 6-bit representation of $+\infty$ is [011100]. Next, the 6-bit representation of $-\infty$ is [111100].

**(2)** Suppose $x \in \mathbb{R}^n$. Then, we have:

- 1-norm:

$$||x||_1 = \sum_{i=1}^{n} |x_i|$$

- 1-norm:

$$||x||_2 = \left( \sum_{i=1}^{n} |x_i|^2 \right)^{\frac{1}{2}}$$

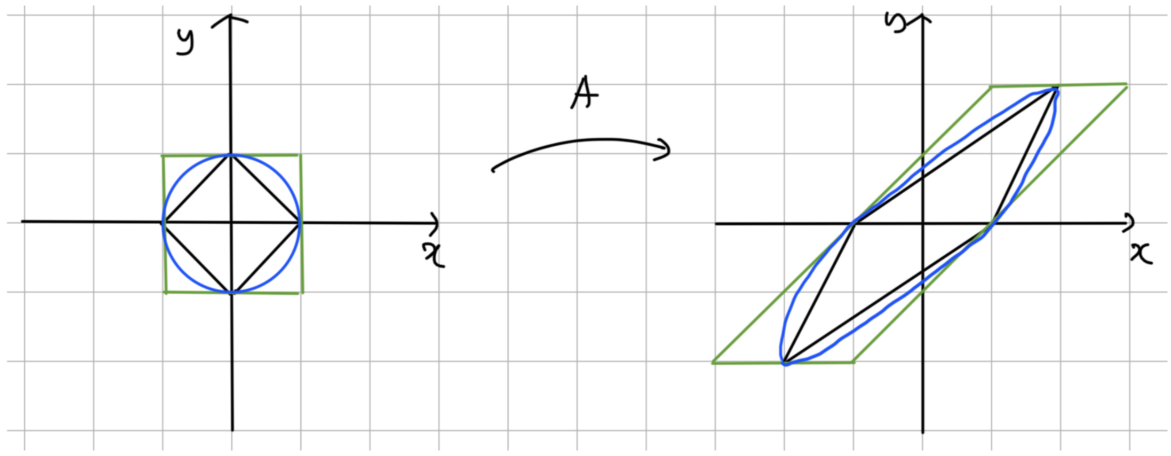
- $\infty$-norm:

$$||x||_\infty = \max_{1 \leq i \leq n} |x_i|$$

**(3)** First, note that:

$$A \begin{pmatrix} 1 \\ 0 \end{pmatrix} = \begin{pmatrix} 1 & 2 \\ 0 & 2 \end{pmatrix} \begin{pmatrix} 1 \\ 0 \end{pmatrix} = \begin{pmatrix} 1 \\ 0 \end{pmatrix}$$
$$A \begin{pmatrix} 0 \\ 1 \end{pmatrix} = \begin{pmatrix} 1 & 2 \\ 0 & 2 \end{pmatrix} \begin{pmatrix} 0 \\ 1 \end{pmatrix} = \begin{pmatrix} 2 \\ 2 \end{pmatrix}$$

Hence, we have:




where black line is 1-norm, blue line is 2-norm, and green line is $\infty$-norm.