# ICS-E4020 Programming Parallel Computers - Assignment 2

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April 26, 2015

## 1 Introduction

In this problem we had to find the correlation between the rows of the image. In the brute force force, we first normalised the rows to have zero mean and unit variance. And then we performed the matrix multiplication $XX^T$. Where X is the matrix with normalised rows.

The benchmark values (in secs) obtained when the brute force approach(CP 1) . The time values are calculated by dividing the time values by a factor of $nx * ny * ny$. This value represents the time for each multiplication. The table for different sizes of number of rows and columns is in the figure below. In addition to that the plot for number of rows is 1000 and for different number of columns against the time for each multiplication is given below:

| no_rows\no_cols | 100 | 1000 | 2000 | 4000 |
|---|---|---|---|---|
| 100 | 1E-09 | 4.2E-10 | 3.8E-10 | 3.7938E-10 |
| 1000 | 1E-09 | 4.14E-10 | 4.19E-10 | 4.2006E-10 |
| 2000 | 4.5E-10 | 4.22E-10 | 4.19E-10 | 4.1691E-10 |
| 4000 | 4.75E-10 | 4.22E-10 | 4.19E-10 | 4.1717E-10 |

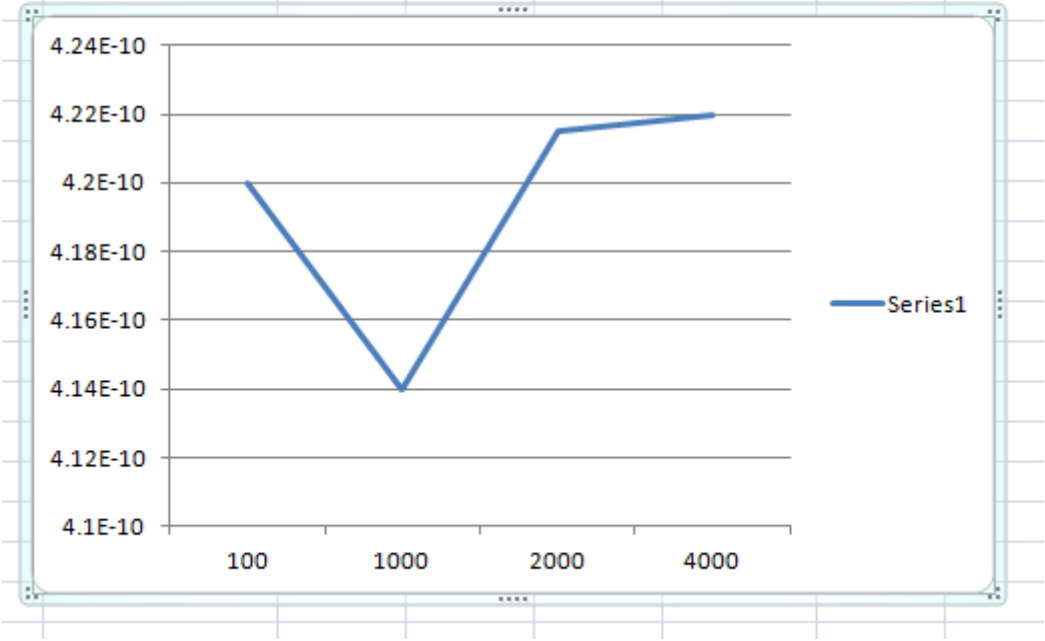


Figure 1: Excel ScreenShot of the table and the plot for CP1

The values are pretty much constant.

## 2 CP2

In CP2, we parallelize the operations and the time for each multiplication using 8 threads is given below:

| no_rows\no_cols | 100 | 1000 | 2000 | 4000 |
|---|---|---|---|---|
| 100 | 0 | 1.7E-10 | 7.75E-11 | 1.06E-10 |
| 1000 | 2E-10 | 7.5E-11 | 7.45E-11 | 1.06E-10 |
| 2000 | 2E-10 | 7.5E-11 | 8.9E-11 | 1.11E-10 |
| 4000 | 2E-10 | 7.58E-11 | 1.3E-10 | 1.03E-10 |

Figure 2: Excel ScreenShot of the table for CP2

# 3 CP3

In CP3 we use vector operations and timings similar to CP1 is tabulated and plotted below:

| no_rows\no_cols | 100 | 1000 | 2000 | 4000 |
|---|---|---|---|---|
| 100 | 0 | 1.7E-10 | 1.65E-10 | 1.65E-10 |
| 1000 | 5E-10 | 1.79E-10 | 2.03E-10 | 2.24E-10 |
| 2000 | 5E-10 | 2.07E-10 | 2.28E-10 | 2.28E-10 |
| 4000 | 2.5E-10 | 2.54E-10 | 2.57E-10 | 2.57E-10 |

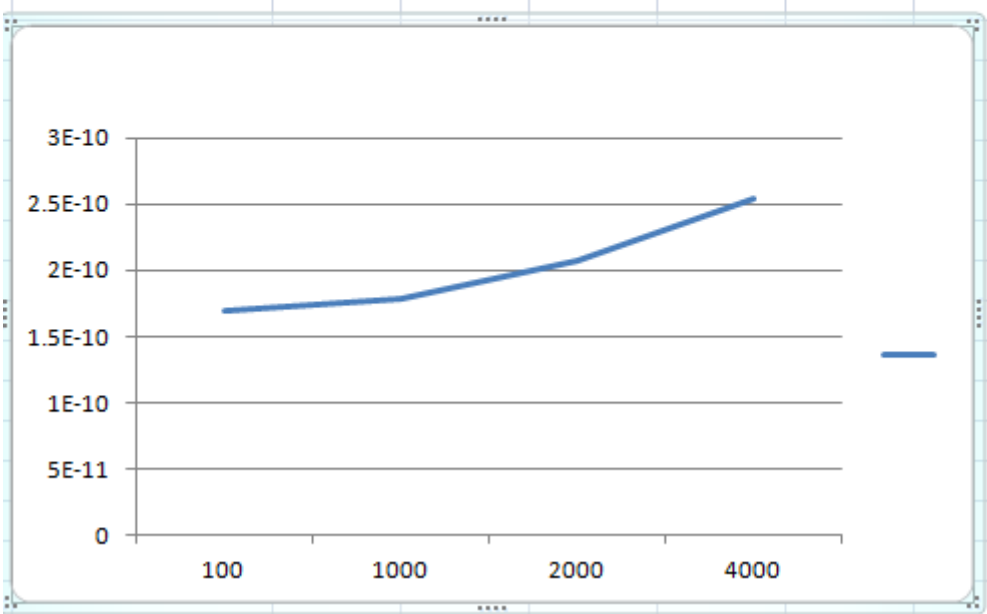


Figure 3: Excel ScreenShot of the table and the plot for CP3

# 4 CP4

In CP4 we perform block matrix multiplication and timings similar to CP1 is tabulated and plotted below:

| no_rows\no_cols | 100 | 1000 | 2000 | 4000 |
|---|---|---|---|---|
| 100 | 0 | 1.7E-10 | 1.4E-10 | 1.38E-10 |
| 1000 | 2E-10 | 1.71E-10 | 1.61E-10 | 1.6E-10 |
| 2000 | 3.5E-10 | 1.69E-10 | 1.68E-10 | 1.63E-10 |
| 4000 | 4.5E-10 | 2.12E-10 | 2.08E-10 | 2.06E-10 |

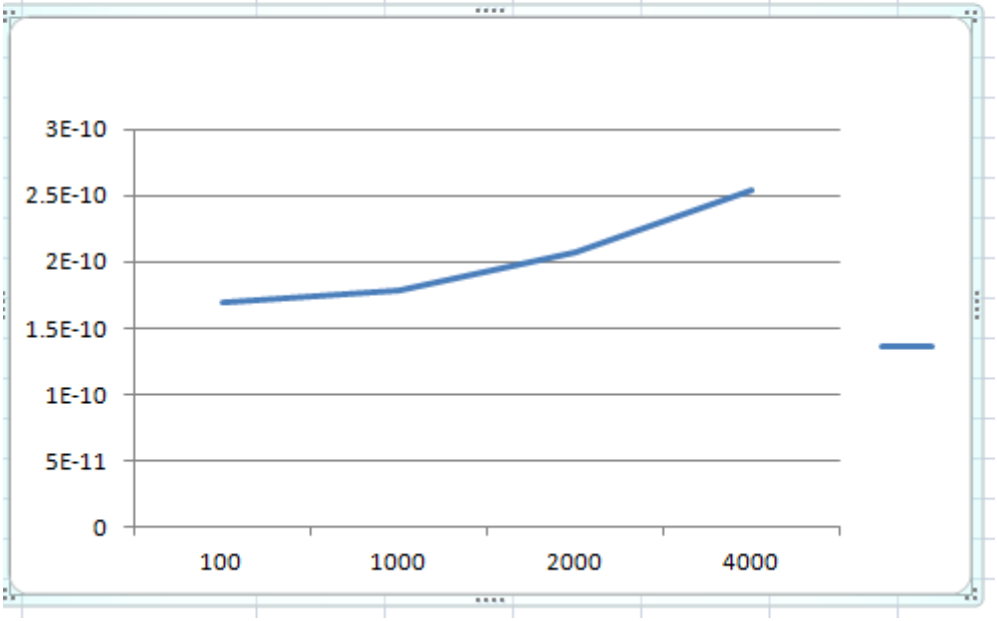


Figure 4: Excel ScreenShot of the table and the plot for CP4

# 5 Conclusion

The plot combining CP1, CP3 and CP4 is given below:

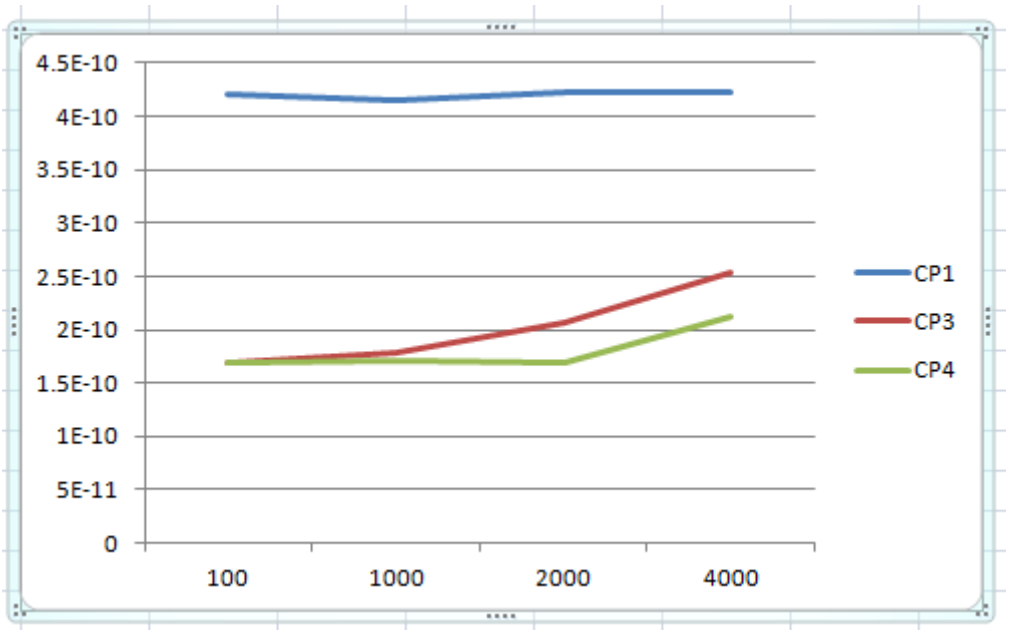


Figure 5: Excel ScreenShot of the table and the plot for CP3

We can see that by implementing cache blocking with the vector operations the performance is way better than the naive approach.