

CS 594 – Scientific Computing for Engineers  
Assignment #1  
January 8<sup>th</sup>, 2020  
Due: January 22<sup>nd</sup>, 2020  
Simple Operations

I would like you to implement a version of the following mathematical operations:

- the 2-norm of a vector,

$$\|x\|_2 = \sqrt{x^T x} = \sqrt{\sum_{i=1}^n x_i * x_i}$$

- matrix - vector multiplication,

$$y = y + A * x$$

$$y_i = y_i + \sum_{j=1}^n A_{i,j} * x_j, \text{ for } i = 1, \dots, n$$

- matrix multiplication

$$C = C + A * B$$

$$C_{i,j} = C_{i,j} + \sum_{k=1}^n A_{i,k} * B_{k,j}, \text{ for } i, j = 1, \dots, n$$

The point of this assignment is not to write software, but to look at the performance for each of your implementations and try to explain why you are getting the performance you see and what you could do to increase the performance. You should produce a software implementation for each and run some experiments on various computers with different processors. I would like to see a report and analysis of your results; perhaps some plots of your performance data for n between say 10 and 1000. Please verify and convince me that you are computing the correct results in each case. Let me know what computers you used and how you are getting the performance results as well.

You can find out information on various processors at:

<http://www.cpu-world.com/CPUs/index.html>

<http://www.cpu-world.com/sspec/index.html>

## CS 594

### Notes on Assignment #1

The programming that is part of this homework is not the important aspect of the assignment; it is the analysis of what your program is doing. In particular I'm interested in the following, first you should convince me that your program is doing the right thing, that is you should verify that you are computing the "correct" solution. You can do this by using data that when used with your program produces a known result or solution. (Don't use zeros or ones in your data as that may give an incorrect timing behavior.) Or you can compare your results with a routine from a standard numerical library (that you assume is correct) and compute a "residual", say something like:

`|| your solution – known solution ||`

I would like you to analyze your timing results by graphing the rate of execution (ops/sec) as you vary the size of the problem.

I would also like an analysis of the rate you achieve to the theoretical peak performance rate of the processor. You should also describe why the performance you are achieving is so different than the peak.

Here's how HW#1 will be scored. 10 points max. 2 for programming, 3 for verification of results, 5 for timing analysis and discussion.