Course Project #1: Matrix-Matrix Multiplication with SIMD Instructions

Due date: Jan. 28

1. Introduction

The objective of this design project is to implement a C/C++ module that carries out high-speed matrix-matrix multiplication by explicitly utilizing x86 SIMD instructions. Matrix-matrix multiplication is one of the most important data processing kernels in numerous real-life applications, e.g., machine learning, computer vision, signal processing, and scientific computing. This project aims to help you gain hands-on experience of (1) SIMD programming, and (2) cache access optimization. It will help you develop a deeper understanding of the importance of exploiting data-level parallelism and minimizing cache miss.

2. Requirement

Your implementation should be able to support (1) configurable matrix size that can be much larger than the on-chip cache capacity, and (2) both fixed-point and floating-point data. Each group should create a Github site that hosts the code/results of all the projects through this semester. Other than the source code, your Github site should contain

(1) Readme that clearly explains the structure/installation/usage of your code
(2) Experimental results that show the performance of your code under different matrix size (at least including 1,000x1,000 and 10,000x10,000) and different data precision (4-byte floating-point, 2-byte fixed-point)
(3) Comparison with native implementation of matrix-matrix multiplication (i.e., without any cache optimization and explicit use of SIMD instructions)
(4) Analysis and conclusion

3. Additional Information

The easiest way to use SIMD instructions is to call the intrinsic functions in your C/C++ code. The complete reference of the intrinsic functions can be found at https://software.intel.com/sites/landingpage/IntrinsicsGuide/, and you can find many on-line materials about their usage. Moreover, matrix-matrix multiplication has been well studied in the industry, and the most well-known library is the Intel Math Kernel Library (MKL), which can be a good reference for you.