18-645: How to Write Fast Code I

Project 2:- Kernel Design

Instructions. A 3-page design document (single column) is to be submitted via Canvas. **The project updates must be submitted as a pdf document. Documents must be submitted individually.**

The main focus of this submission is to design the kernel(s) of the project, and to benchmark the existing implementation. We will schedule a meeting with each team to discuss their design before the due data. Beyond the individual team meetings, team should feel free to use office hours to talk about their projects as well.

Requirements: The document must address the following:

1. *Algorithm Description.* Provide a description of the algorithm(s) you have identified. Specifically, your description of the algorithm(s) must clearly identify the kernels. For each of the identified kernels, you need to specify the following:
   - What are the independent operations?
   - What are the dependent instructions that make up the independent operation?
   - What functional unit(s) are used to compute those instructions?
2. *Performance Peak.* Based on your description of the algorithm(s) and the kernel(s), answer the following questions:
   (a) Describe the machine of your choice (model & architecture)
   (b) What are the latency and throughput of the instructions identified in the previous question?
   (c) Do you have the appropriate SIMD instructions on your machine?
   (d) Are there specialized units that can be used your machine?
   (e) Explain how you computed the theoretical peak of your kernel(s)?
3. *Performance Baseline.* Provide baseline performance plots for the algorithm(s) you have identified. This should be a performance plot based on existing code. The data set use to create these plots should also be the same data set used to test your implementation.
   (a) Provide performance numbers for different input data types and sizes if applicable.
   (b) How close to the theoretical peak is the existing baseline?
4. *Design of your implementation.* This is the main focus of this portion of your project where you are required to design kernels based on the information gathered previously. Explain what are the parameters that are important for determining the size of your kernel(s). These parameters typically correspond to the different dimensions of your algorithmic problems.

   How will SIMD instructions be used? If they are not used, provide reasons why not?

   This should be sufficiently detailed so that it is possible to implement the kernel based on your description.