EECS 471

Final Project

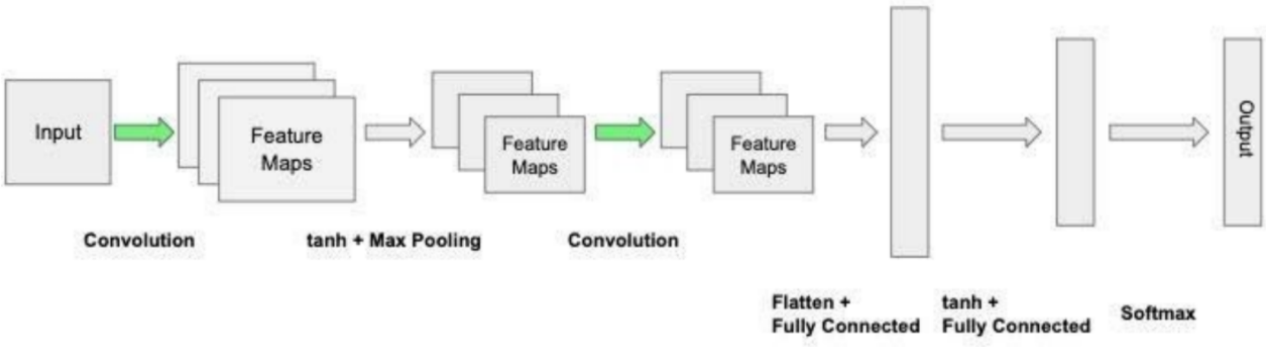
Due date: April 12, 2023 11:59pm

Introduction

- Get practical experience by using, profiling, and modifying MXNet, a standard open-source neural-network framework.
- Demonstrate command of CUDA and optimization approaches by designing and implementing an optimized neural-network convolution layer forward pass.

For a background and introduction to Convolutional Neural Networks we suggest this video.

You will be using a pretrained CNN to predict images from the MNIST-Fashion dataset. The starter code given to you is a correct implementation of the convolution layers and your optimized versions should have identical functionality.



Grading

70% correctness and speed

- *Correctness: you must have 0.7955 (printed near the top of the slurm output) to receive **any** points on the project.* In other words, your implementation must match the same functionality as the starter code. You will receive 0 points for an incorrect implementation.
- *Speed: you must achieve **under 0.3 seconds** for both layers combined to get full points on the project*

30% final project report

- See *Final Report* section below for what is expected from you.

Setup

You will be developing on Great Lakes.

From your personal folder (*eecs498f21_class/<uniqname>),* run the following commands in sequence to pull the code for the final project into your personal workspace and setup (note, this will take a while):

tar -xzvf /scratch/eecs471f22_class_root/eecs471f22_class/shared_data/final_project.tar.gz

cd final_project

NOTE FOR THE NEXT COMMAND: get-pip.py may print out a warning about it installing pip to a directory that isn't in your path. If this happens, make sure to add the directory to your path. Also, get-pip.py reinstalls pip. If you use Great Lakes for more than just this class, make sure you don't mess your own use cases up.

chmod 777 *.sh

./setup_student.sh

sbatch ./build_student.sh

(Compilation can take up to 2 hours the first time. You may want to use something like `screen` if your connection is unstable)

Directory Layout

Once you pull the code into your workspace, there will be a folder named “final_project” with the following items

final_project

- -fashion-mnist (d)
- -incubator-mxnet (d)
- -models (d)
- -submit (d)
- -new-forward.cuh (f)
- -run_student.sh (f)
- -build_student.sh (f)
- -get-pip.py (f)

fashion-mnist contains images from the fashion-mnist dataset that your CNN will be classifying.

incubator-mxnet contains the source code for the mxnet library, the code you write will be compiled into this with your custom implementation.

models contains a JSON description of a pretrained CNN that will use your implementation of the forward pass convolution layer to classify the fashion-mnist images.

submit contains a python script submission.py that will be run by run_student.sh to run your CNN, as well as a submit_code script that you will use to submit your code for grading. new-forward.cuh is the only file that you should be modifying. We have provided scripts to help you with running your code. Run **sbatch ./build_student.sh** to compile your source code into mxnet (first compilation can take hours, following compilations ~1.5mins), which will allow you to run your implementation by running **sbatch ./run_student.sh**. The profiling info (including timing) will be available in the generated slurm output.

To submit your code, simply run `**./submit_code.sh `.** This will copy your file into the **all_sub** folder, similar to how your other assignments were submitted.

You will be graded based on what source code you have submitted via the submission script in Great Lakes. Make sure that you have your final, working version there at the time of the deadline, as only the latest version will be graded

Optimizations

You must implement at least 2 optimizations to the forward pass convolutional layer, but you will almost definitely need more to get the program to execute **under the maximum allowable runtime of 0.3 seconds**. You have starter code of an extremely naive but correct implementation in the file new-forward.cuh. You can implement the optimizations separately (i.e. they do not need to build on each other), however you must document each optimization's performance effect within your final report and be sure to keep the functions of each optimization you write within your file for your final submission. (see *Final Report* below)

You are encouraged to be creative with your optimizations! Here are some suggestions that you could consider, but feel free to implement one not included below.

Suggested optimizations:

- Shared Memory convolution
- Weight matrix (kernel values) in constant memory
- Loop unrolling
- Unroll + shared-memory Matrix multiply
- Kernel fusion for unrolling and matrix-multiplication
- Exploiting parallelism in input images, input channels, and output channels
- Multiple kernel implementations for different layer sizes
- Sweeping various parameters to find best values (block sizes, amount of thread coarsening)

Final Report

As you implement your optimizations, you are required to document their effect on performance.

Create a document and describe each optimization you implemented, including why you selected this optimization, screenshots of profiler output, and the output of each layer's timing with this optimization. Describe in detail how you implemented the optimizations.

Leaderboard and Class competition

Top team on the leaderboard (coming soon!) will get a prize!