CS 515, Fall 2018
Jetson TX-1 Project
Due date: Friday, December 14, 2018

The goal is to experiment with different forms of parallelism - multi-threaded parallelism using OpenMP and "vector" parallelism on GPUs using NVIDIA's CUDA language - and explore the **tradeoff space** of

Execution Time vs. Energy vs. Power

for a single image processing application, namely an image smoothing code (QuickShift). The project consists of an evaluation of QuickShift running on a single CPU, multiple cores, or the GPU of NVIDIA's single board, heterogeneous Jetson TX-1 system. The deliverable of the project is a written report that describes your experiments and presents the results. You may choose different aspects of the application to explore, for example different images and parameter settings. A deep understanding of the application's code is not required. Given the input image, the application reports the execution time in milliseconds. A working knowledge of Linux, C++ and OpenMP is desirable, latter if you want to change the number of cores used. Important metrics to report are:

Execution Time: reported by the application (milliseconds)

Power: voltage * current (reported by the powerstrip

Energy: power * execution time; you may assume that the power is constant; in general, it is the integral under the power curve.

1. Jetson TX-1 board

A detailed description of the board that you will be using can be found online.
NVIDIA's TX-1 board: http://elinux.org/Jetson_TX1

Please feel free to just perform a google search to find more information about this system. We have a cluster of them available (8 TX-1). You can remotely log into these systems from an iLab machine and run your application code. You need to be on a machine at Rutgers, so directly logging into the TX1 boards from outside is not possible.

You will share your TX1 board with three other students. Each machine will have a subdirectory named by NetIDs of the students on the particular machine. Since you are sharing the TX1 boards, please be considerate. If you want to run a set of experiments, please let the others know. When you log onto the machine, check who else is there and find out what they are doing. Email using

NetID@scarletmail.rutgers.edu may be a good way to communicate, assuming that everyone is reading his/her email.

2. mFI power strips

The power supply of each board in our TX cluster is connected to a "smart" mPower Pro 8 power strip https://www.ubnt.com/mfi/mpower/ . This allows the measurement of power in real time. There is a web interface that allows instantaneous power readings. In addition, you can remotely log into the power strips and perform different logging commands, again **you should be on a ilab machine to do this**. There are two 8 port power strips for our TX-1 single board systems.

3. QuickShift application

There are three versions of this code, one sequential (cpu), one using multi-threading with OpenMP (omp), and one using the 256 core GPU (gpu). The application has two parameters, tau and sigma, that can influence the quality of the program outcome. The application takes a single image as input, for example "flowers2.pnm":

The application computes pixels that have similar color values. Significantly different color values indicate object boundaries. The image within such boundaries is then smoothened, i.e., made identical. The notion of "identical" and the size of the regions that can be smoothened can be adjusted, resulting in different output image qualities. The code is written in C++. The outcome for tau=6 and sigma=10 (default values) is shown below:

4. How to get started?

We have currently 8 TX1 boards available to us, namely tx2.cs.rutgers.edu through tx9.cs.rutgers.edu . Since we have 24 students in the class, three students will be assigned the same machine. Each board has the QuickShift application pre-installed in three separate directories, named alpha, beta, and delta. The user ID for each system is "**csuser**". You can log onto your machine (e.g., tx4) by saying:

ssh –X csuser@tx4.cs.rutgers.edu

If you want move things off the board, use the sftp command.

I will email you your password, your assigned TX1 system, and your assigned directory (alpha, beta, or delta). As the first step, log into your system and rename your directory to your Rutgers NetID (use the "mv" command, for example "mv beta aaa999"). Once you are in your directory, say "make", and the executable "quickshift" is generated. To clean up, say "make clean".

You can call quickshift on a file using different computing resources as follows:

```
./quickshift  --file  <input.pnm> --mode cpu
./quickshift  --file  <input.pnm> --mode omp
./quickshift  --file  <input.pnm> --mode gpu
```

If you just say ./quickshift, it gives you the possible command line options.

Values for sigma and tau can be provided using -- sigma and -- tau command line options. The default is 6 and 10, respectively. After you executed quickshift, the resulting image can be found in <input>-gpu.pnm, <input>-cpu.pnm, and <input>-omp.pnm

The basic image viewer on Ubuntu is called "eog". You can visually inspect the output to see whether they are all identical. You may also be able to use "display".

Information about power strips together with their passwords and the port assignments of each of our TX boards is provided in file PowerStripsInfo.txt in the csuser home directory on each TX system. DO NOT SWITCH OFF YOUR POWER SUPPLY. DO NOT DELETE ANY FILES THAT ARE NOT YOURS.

The pictures subdirectory contains a few pictures that you can use in your experiments. Please copy the picture you want into your subdirectory, or use a soft link. The initial picture flowers2.pnm is already in your subdirectory.

4. Grading

Grading is based on a written report (up to three pages). No code needs to be submitted.
You may "play" with different tau and sigma values for QuickShift, or use different sets of images, for instance the images provided to you in directory "test-images". You may also want to run quickshift on different numbers of OpenMP cores (2, 3, or 4, which is the default). Since the project is rather research related, projects are graded on effort rather than the final outcome. Show what you did in a form that makes it accessible to a reader not familiar with the issues. Go for quality rather than quantity. Graphs are good tools to convey a trend and/or tradeoffs. Is there a lesson to be learned here?

5. Project Questions

All project related questions should be posted on piazza. Thanks!