Advanced Computer Architecture

GPU (CUDA) Image Filters

Part A: Sobel Filter Code

Please see the attached .cu files. The program works with the following command:
./filter -filter -file -out
where the optional flags are:

-filter: select from sobel, average, boost, 5x5, or 5x5a

- sobel: applies sobel filter with 3x3 kernel sobel mask, seen below

- average: applied average filter
- boost: applies boost filter
- 5x5: applies sobel filter with 5x5 kernel sobel mask, seen below

- 5x5a: applied sobel filter with 5x5 kernel sobel mask, seen below:

-file: select the desired input file to apply filter to. The default is lena.bmp, which must be in the same directory as the executable

-out: select the desired name for the output file containing the filtered image. The default is CPU_output.bmp

Part B: Sobel Filter Execution Times

Input File	GPU Execution Time [ms]	CPU Execution Time [ms]	Speedup
lena.bmp	0.244000	2.143000	8.783
dublin.bmp	2.650000	54.265999	20.178

Part C: Average Filter Execution Times

Input File	GPU Execution Time [ms]	CPU Execution Time [ms]	Speedup
lena.bmp	0.244000	0.907000	3.717
dublin.bmp	2.715000	33.608002	12.379

Part D: Boost Filter Execution Times

Input File	GPU Execution Time [ms]	CPU Execution Time [ms]	Speedup
lena.bmp	0.249000	1.838000	7.382
dublin.bmp	2.756000	52.383999	19.007

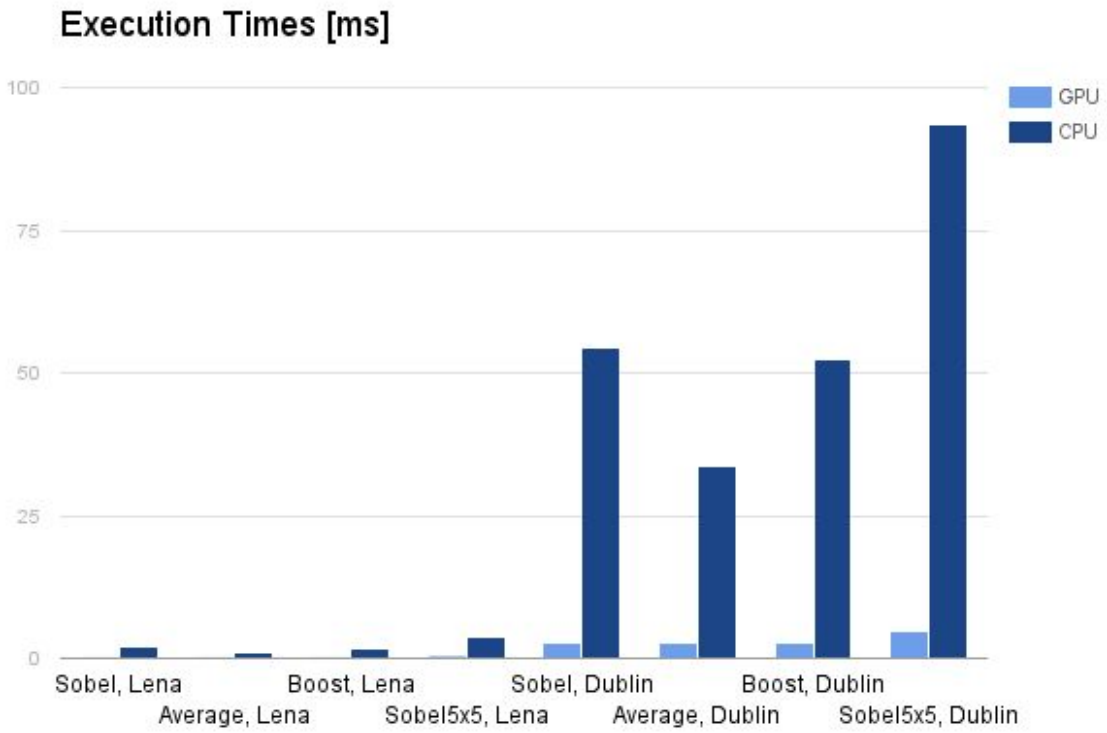
Part E: Sobel Filter with 5x5 Kernel Comparison

Input File	GPU Execution Time [ms]	CPU Execution Time [ms]	Speedup
lena.bmp	0.435000	3.891000	8.945
dublin.bmp	4.730000	93.682999	19.806

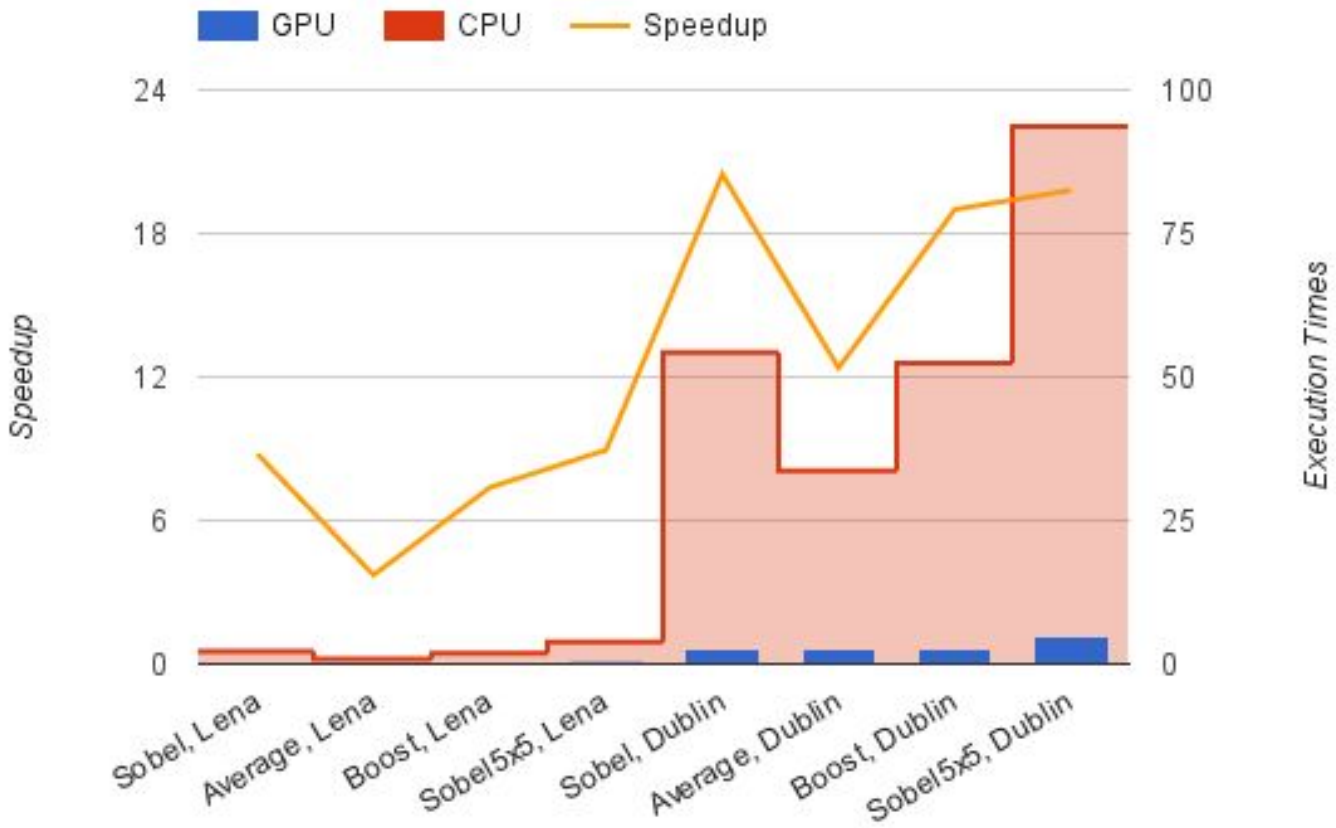
Input File	3x3 GPU Execution Time [ms]	5x5 GPU Execution Time [ms]	Speedup
lena.bmp	0.244000	0.435000	0.561 (slowdown)
dublin.bmp	2.650000	4.730000	0.056 (slowdown)

Conclusion

In all cases, there was a speedup noted when using the GPU to perform the image filtering, despite the handicap included in memory transfer latencies. The difference in execution times can be in the graph below



The speedup increases with the size of the file being filtered, as seen in the graph below. The larger files resulted in approximately a speedup with a factor of 20, while the smaller files had a speedup of a factor around 3-8.



However, in increasing the kernel size from a 3x3 to a 5x5, the GPU actually experienced a slowdown. There was less of a slowdown in the larger image, so perhaps an even larger image will be required to reap the benefits of a increased kernel size.

Samples of the filter outputs are included in a directory named output.