GPU Accelerated 2-D Image Convolution

Charles Yoo | Villanova University | cyoo@villanova.edu
Mentors: Dr. Shadi Alawneh | Oakland University

1 Introduction

Image convolution is an image processing technique used in many fields, such as self-driving vehicles or facial recognition. Since such applications occur in real time, convolution algorithms need to run as quickly as possible. This research seeks to compare CPU and GPU run code to see which is more suitable for the task.

2 Image Convolution

Fig 1. Before (left) and after (right) noise reduction

- Image convolution is used to manipulate images
- Examples:
  - Noise reduction (to correct color)
  - Image sharpening
- Convolution algorithms process every pixel in an image and involve many calculations.

3 CPU vs GPU

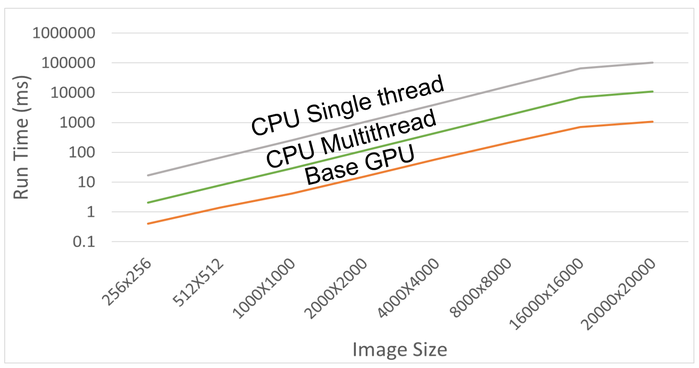

Fig 3. CPU vs GPU Calculation Times

- Single thread uses one CPU thread
- Multithread uses 12 CPU threads
- Base GPU uses both CPU and many GPU threads
- Graphs in **log** scale

- Base GPU has much faster calculation times
- CPU codes have faster allocation times
  - Multithread is faster than single thread

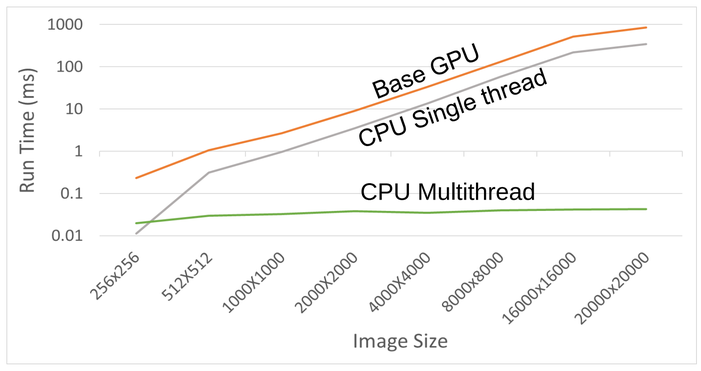

Fig 4. CPU vs GPU Allocation Times

4 Different GPU Codes

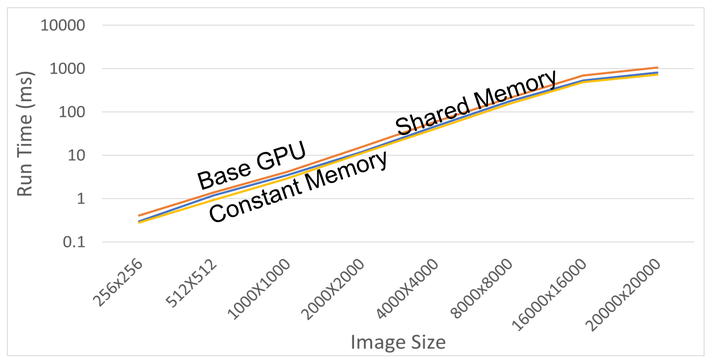

Fig 5. Different GPU Calculation Times

- Base GPU is unoptimized
- Shared memory preloads image
- Constant memory caches data

- Shared memory and constant memory have faster calculation times
- Allocation times the same for all versions

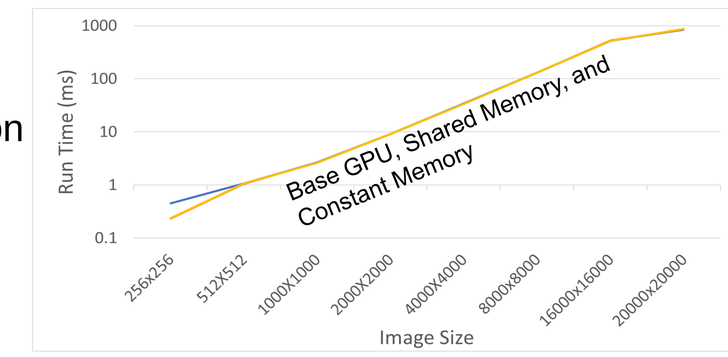

Fig 6. Different GPU Allocation Times

5 Discussion

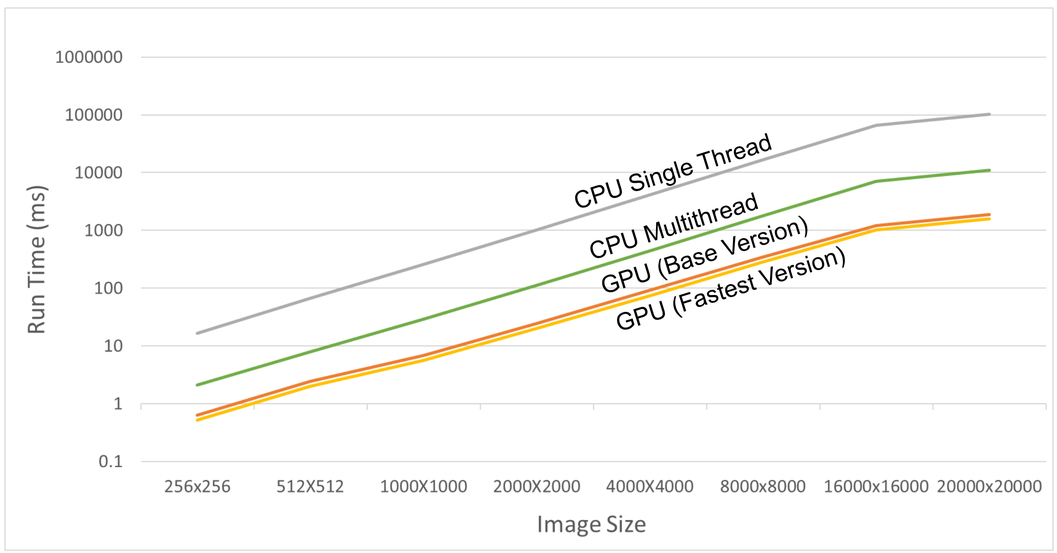

Fig 7. CPU vs GPU Total Times

- Noticeable difference between GPU codes and CPU ones
- The difference in total times increases with larger images
  - (Look at y-axis scaling of graph)
- Little difference between the base and fastest GPU codes

6 Conclusions

- GPU is significantly faster than CPU
  - Especially for larger images
- GPU speed is limited by memory allocation and data transfers
  - Important to optimize
- Biggest jump in performance comes from using GPU over CPU
  - Optimizations to GPU offers marginal improvements
- Easier to add more cores to GPU than CPU
  - GPU offers more potential

ApREECE: Applied Research Experience in Electrical and Computer Engineering REU PROGRAM AT OAKLAND UNIVERSITY

This program was supported by the National Science Foundation Grant No EEC-1659650. Additional support was provided by the School of Engineering and Computer Science at Oakland University.