Parallel Seam Carving

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Introduction

Seam carving is an effective way of resizing images while maintaining the clarity of the most significant content. This method can reduce the dimensions of a digital image without any discernable warping of the content portrayed in the original image. This allows the aspect ratio of an image to be altered in a way that preserves the subjects by eliminating the least important sections.

When a large image needs to be greatly reduced in size, performing seam carving can require significant computational resources. This can take a long time with a serial program. The purpose of this project will be to determine what kind of speedup can be achieved through parallelization of distinct components of a seam carving algorithm. In the algorithm outlined below, the computation of the energy function and the generation of the seams will be parallelized. This will be tested and compared against a serial implementation. Although attempts have been made to improve the efficiency of the seam carving process in the past, this project will determine whether this explicit serial implementation can benefit from parallelization.

Algorithm

1. Store each pixel of the original image and obtain the desired dimensions
2. Remove seams from the image until it is the desired dimensions
3. For each seam to be removed from the image:
    - Compute the energy of each pixel based on an energy function
    - Compute the seam with the least total energy relative to all other possible seams
    - Remove the seam with the least total energy
4. Save the carved version of the image in the desired format

Background

Extensive research has already been conducted for optimal energy functions and dynamic removal of seams in serial. Plenty of background information can be found in the cited paper: *Seam Carving for Content-Aware Image Resizing*, by Shai Avidan and Ariel Shamir. The cited wikipedia page for the concept also provides an adequate summary.

Initial Findings

A serial implementation of the algorithm produced by the group can be found here: http://datahole.ddns.net/cmsc483/seam_carver.html

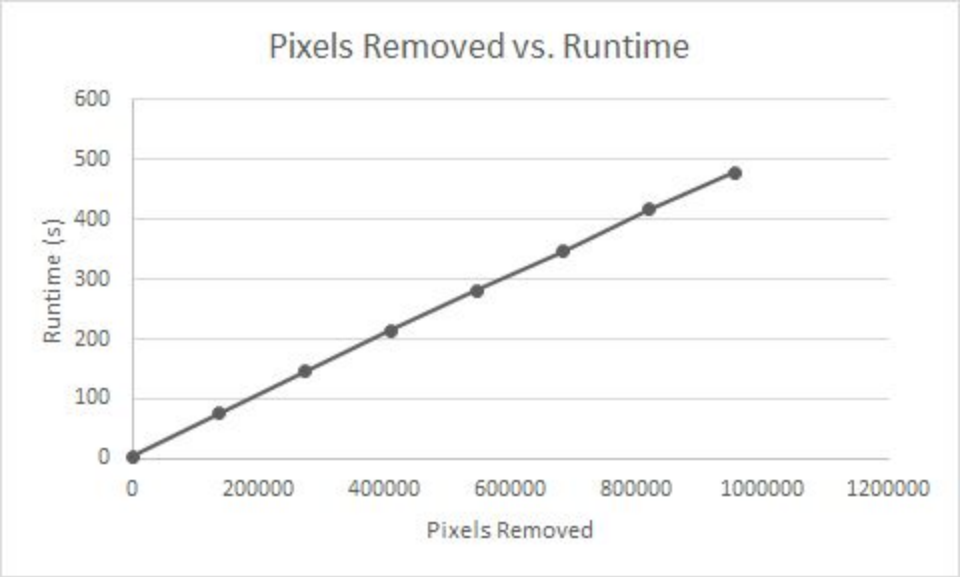

Chart 1. Our initial analysis of the serial algorithm revealed a runtime of $O(n)$.

Technical Plan

Completed (see Initial Findings)

- Serial implementation of the algorithm
- Testing of the serial implementation

To-do

- Parallel implementation of the energy function
- Testing the program with only the energy function parallelized
- Parallel implementation of seam generation
- Testing the program with only seam generation parallelized
- Combining parallel implementations of energy function and seam generation
- Testing the fully parallelized program
- Generate graphs with test data for use with comparison and for the final write-up
- Analysis of tests in comparison to serial implementation tests and to each of the other tests using the generated graphs and raw data
- Initial report write-up including analysis and graphs
- Final conclusions and technical report compilation

Final Report Outline

- Introduction/Motivation
    - Purpose/uses of seam carving
    - Expected advantage of parallelization
- Background
    - General information on seam carving
    - Energy function explanation
    - Dynamic programming relevance
- Methods
    - An explanation of the components of the algorithm
    - How the components of the algorithm were parallelized
- Results
    - Speedup factor of separate parallel components
    - Speedup factor of combined parallel components
    - Graphs illustrating results of components testing and relationships
- Discussion
    - Analysis of speedup factor in relation to the number of processors
    - Analysis of graphs of results
    - Success of expected schedule
    - How expected difficulties were resolved

Schedule

Task	Completed by
Complete project proposal	March 10
Implement energy function	March 17
Test energy function	
Implement seam generation	March 31
Test seam generation	
Combine parallel implementations	April 14
Test combined implementation	
Analysis	April 28
Complete final report	May 10

Contribution

Both of the group members will plan and design the parallelized version of the algorithm together. Implementation will be done individually and divided up as equally as possible. Analysis will also be done individually. Testing and compilation of the final report will be a collaborative effort.

Potential Difficulties

- The Bluewave server lacks some of the software and library dependencies needed by the CImg library for image manipulation.
    - The group will contact the server administrator to determine if the dependencies can be installed.
    - Another solution for image manipulation may be required.

Bibliography

Avidan / Mitsubishi Electric Research Labs, Shamir / The Interdisciplinary Center & Mitsubishi Electric Research Labs. Seam Carving for Content-Aware Image Resizing. Retrieved March 5, 2016, from http://www.win.tue.nl/~wstahw/edu/2IV05/seamcarving.pdf
Provides information on the method of seam carving, energy functions to be used for the process, as well as seam insertion which is not relevant to this project.

Seam carving. (2016, January 16). Retrieved March 05, 2016, from https://en.wikipedia.org/wiki/Seam_carving
Provides a summary of seam carving, the typical algorithm, its downsides, and possible improvements.

CImg Library Project. The C++ Template Image Processing Toolkit. Project Manager David Tschumperle. Included library file for serial implementation. http://datahole.ddns.net/uploads/seam_carver/cimg.h
The CImg library used for image processing to manipulate pixel data.

Berkeley Fluid Animation & Simulation Toolkit. Primary Author James F. O'Brien. Regents of the University of California. Included library files for serial implementation. http://datahole.ddns.net/uploads/seam_carver/sl_io.h
http://datahole.ddns.net/uploads/seam_carver/sl_vector.h
Vector 3 implementation to store pixel data for energy function calculations and comparisons.