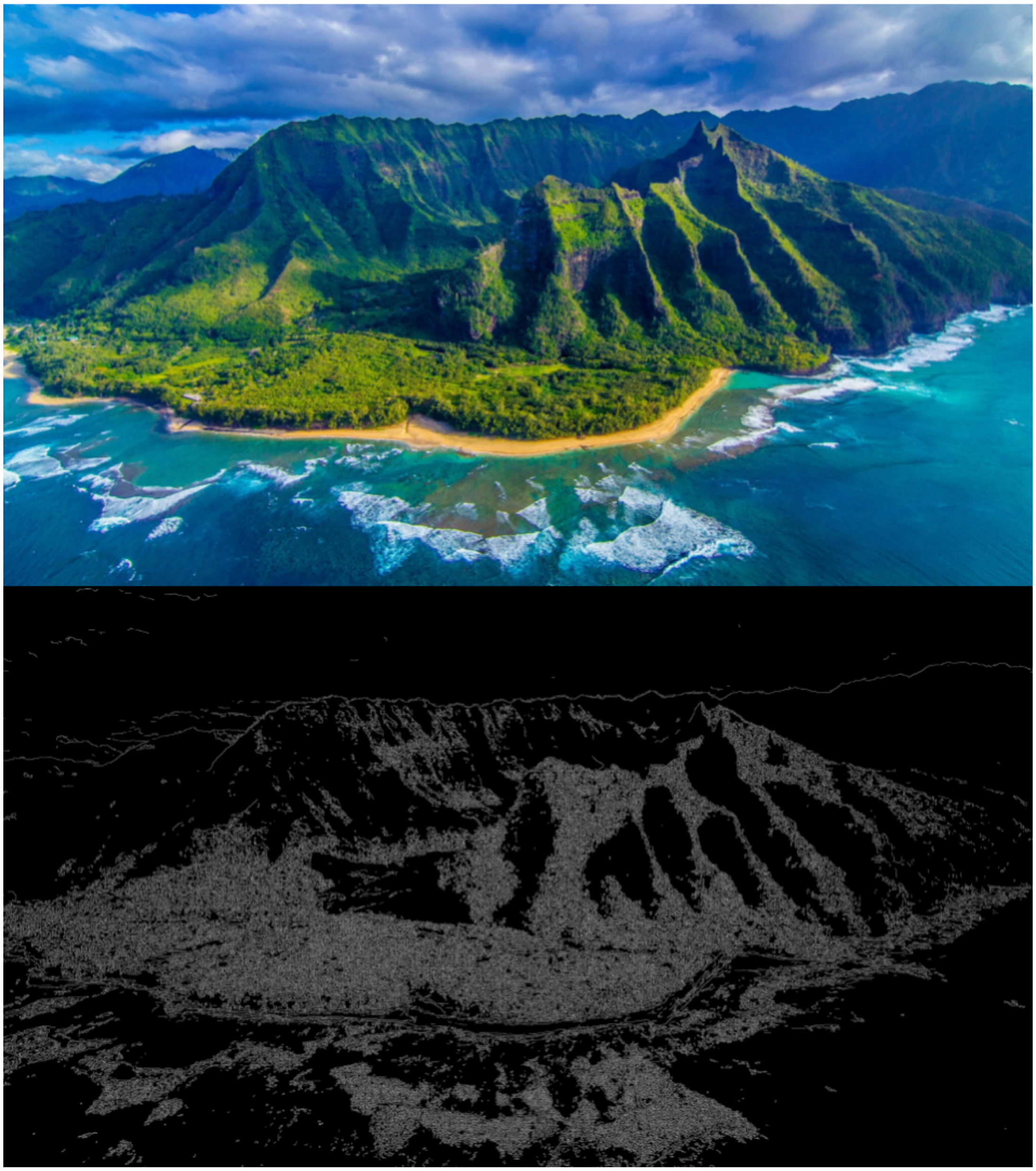
Engraver: GPU and CPU Parallel Implementation of Edge Segmentor

Our project consists of two parts:

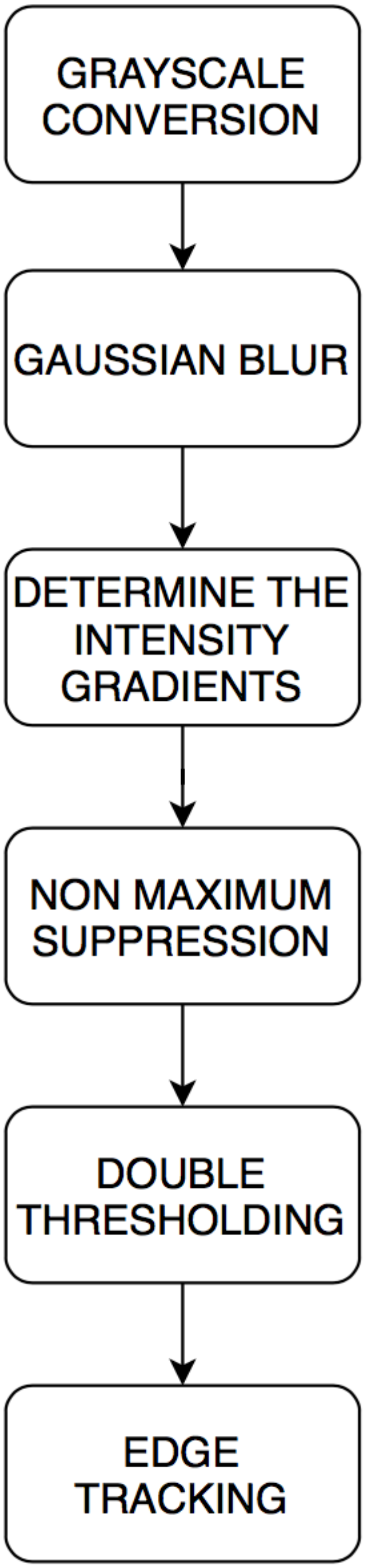
- An edge detector that extracts edges of an image
- An image segmentor that realizes object cutout

For the edge detector, we implemented two parallel versions:

- A GPU version using CUDA
- A CPU version using OpenMP



Canny Edge Detector



GRAYSCALE CONVERSION

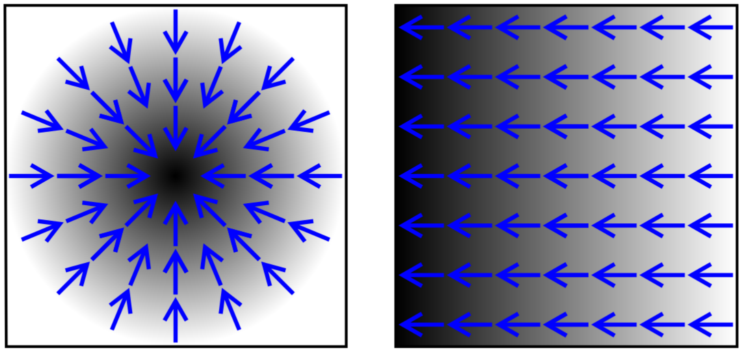
GAUSSIAN BLUR

DETERMINE THE INTENSITY GRADIENTS

NON MAXIMUM SUPPRESSION

DOUBLE THRESHOLDING

EDGE TRACKING



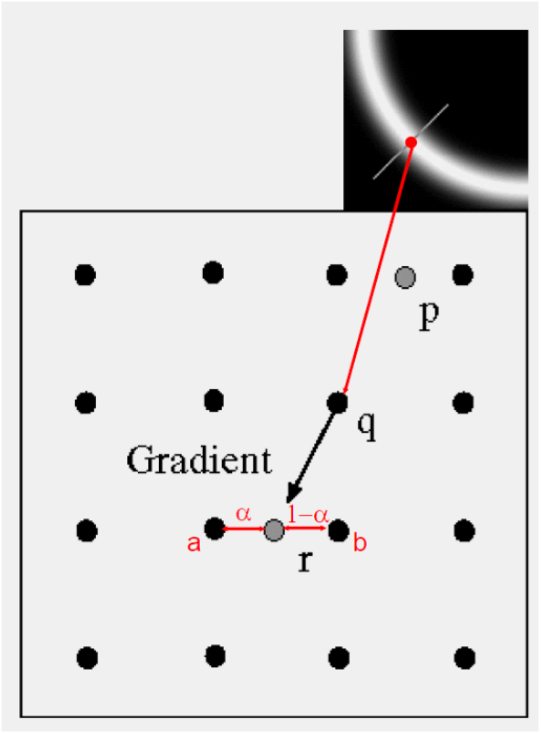
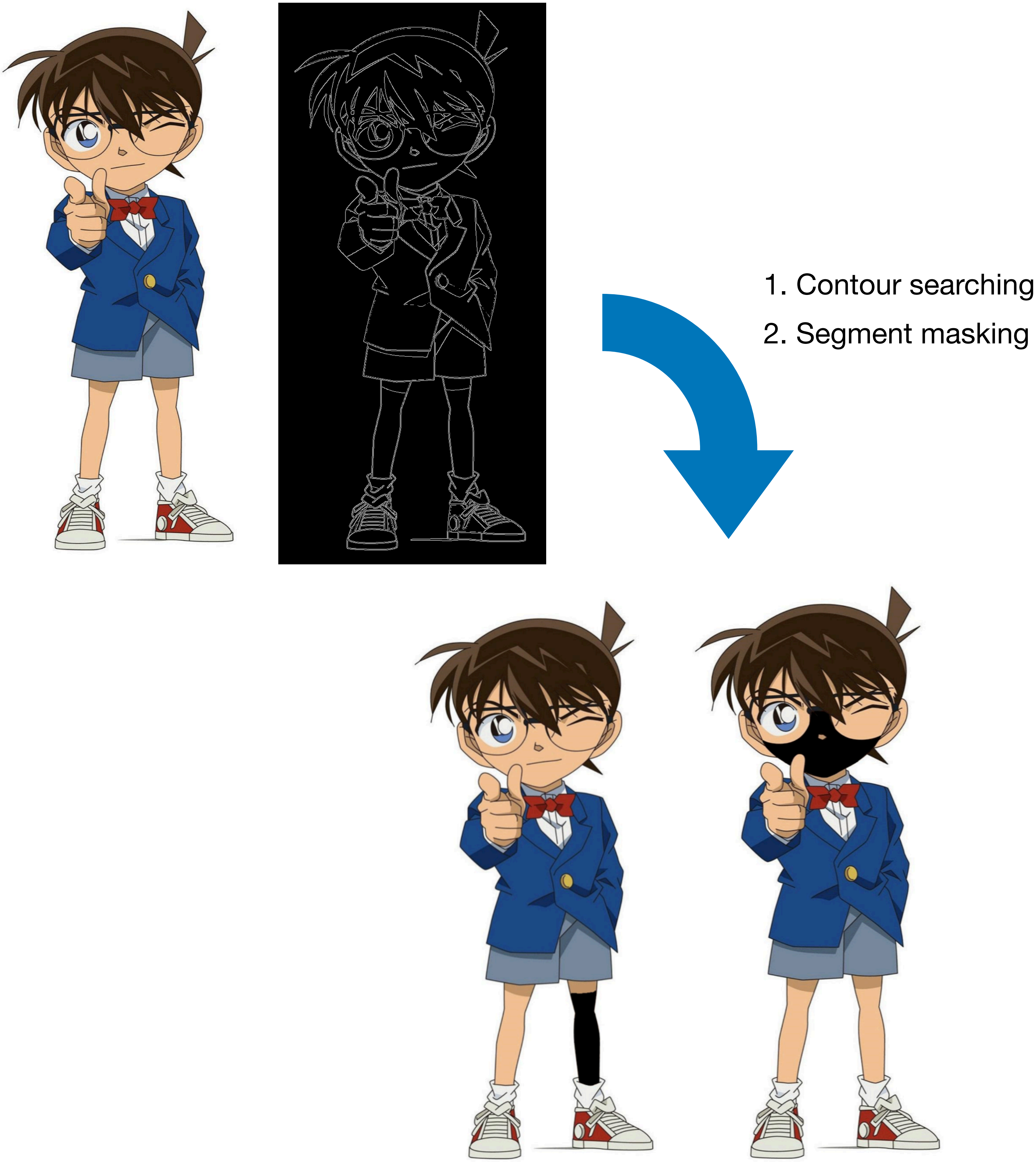
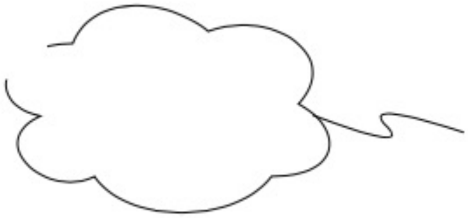


Image Segmentation & Object Cutout

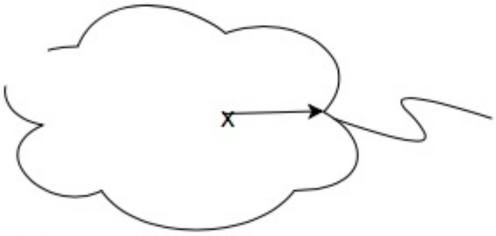


1. Contour searching
2. Segment masking

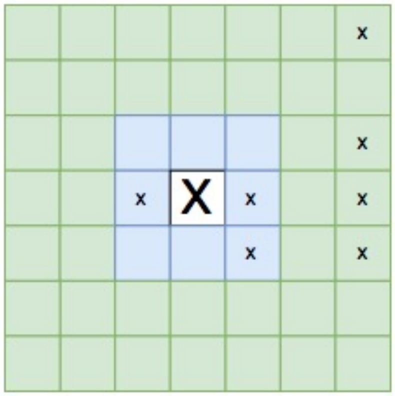
Image Segmentation Algorithm



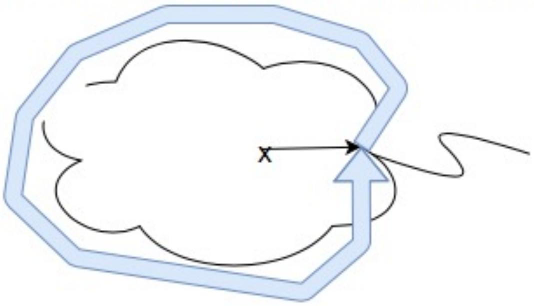
Step 1: Find the edge with Canny edge detector.



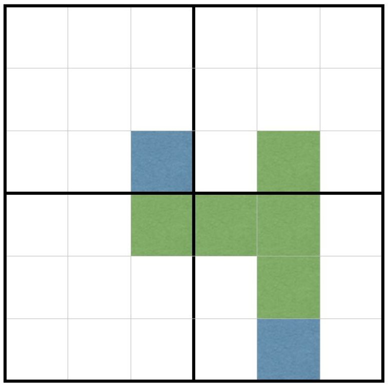
Step 2: Find a random nearby edge point.



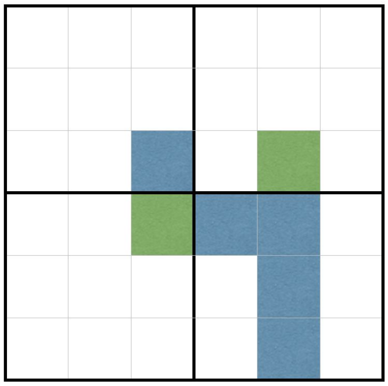
Step 3: Recursive search on nearby points.
The blue part represents the neighbors to be searched.
The green part represents a jump. Will only be searched when no blue pixel exists.



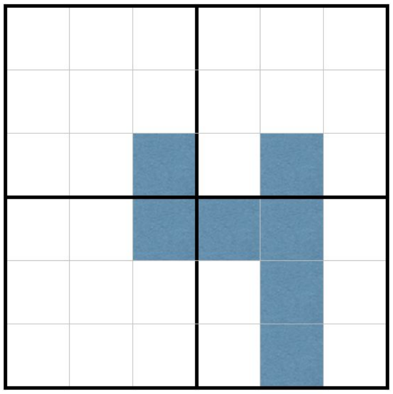
Step 4: Find cycle that returns to the starting point.



Step 1: Find all STRONG(blue) and WEAK(green) edges.

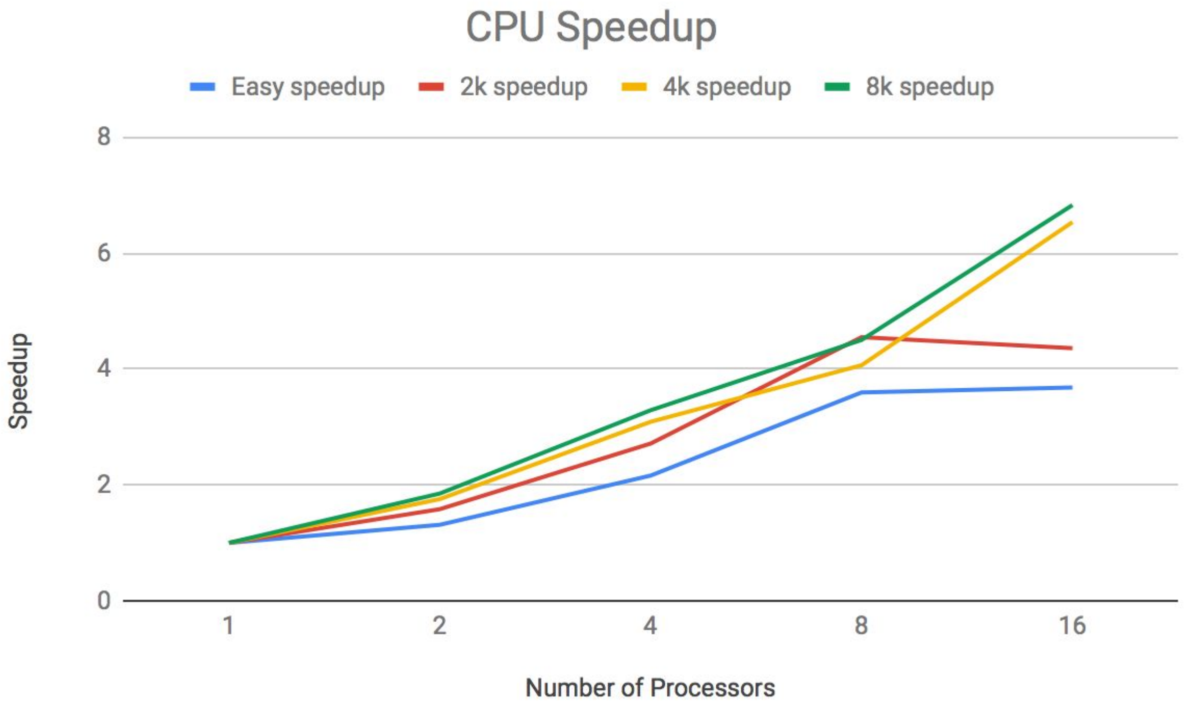


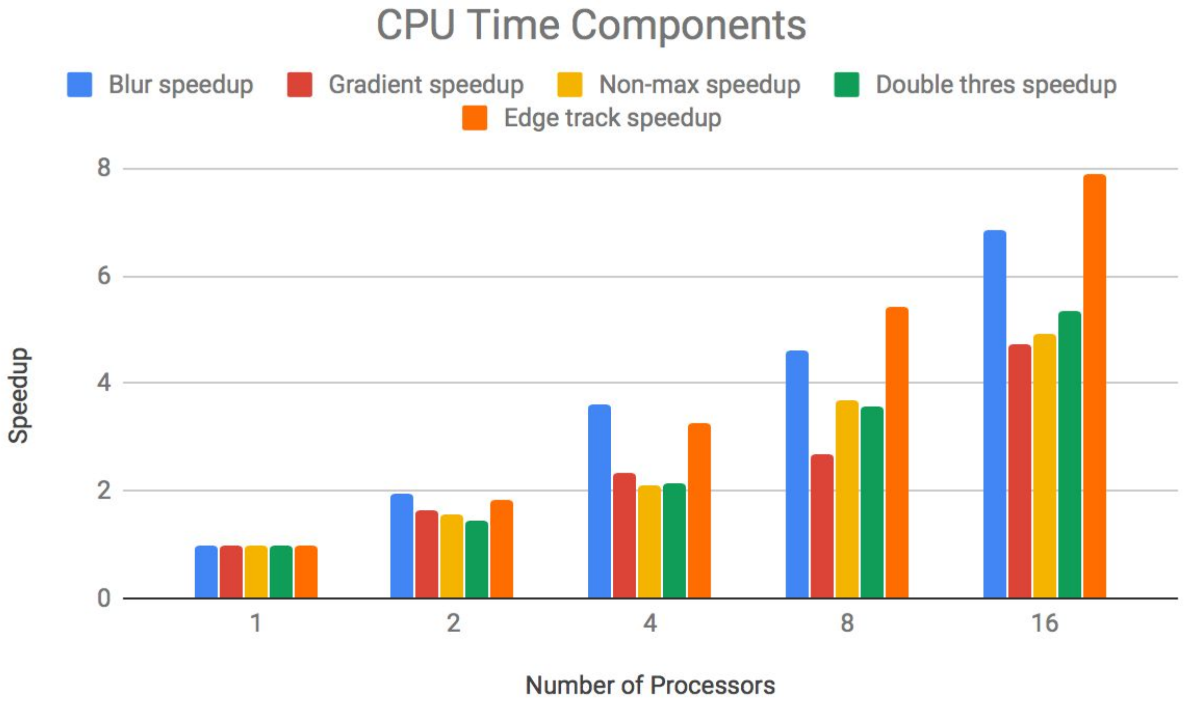
Step 2: Perform Connectivity analysis within block.

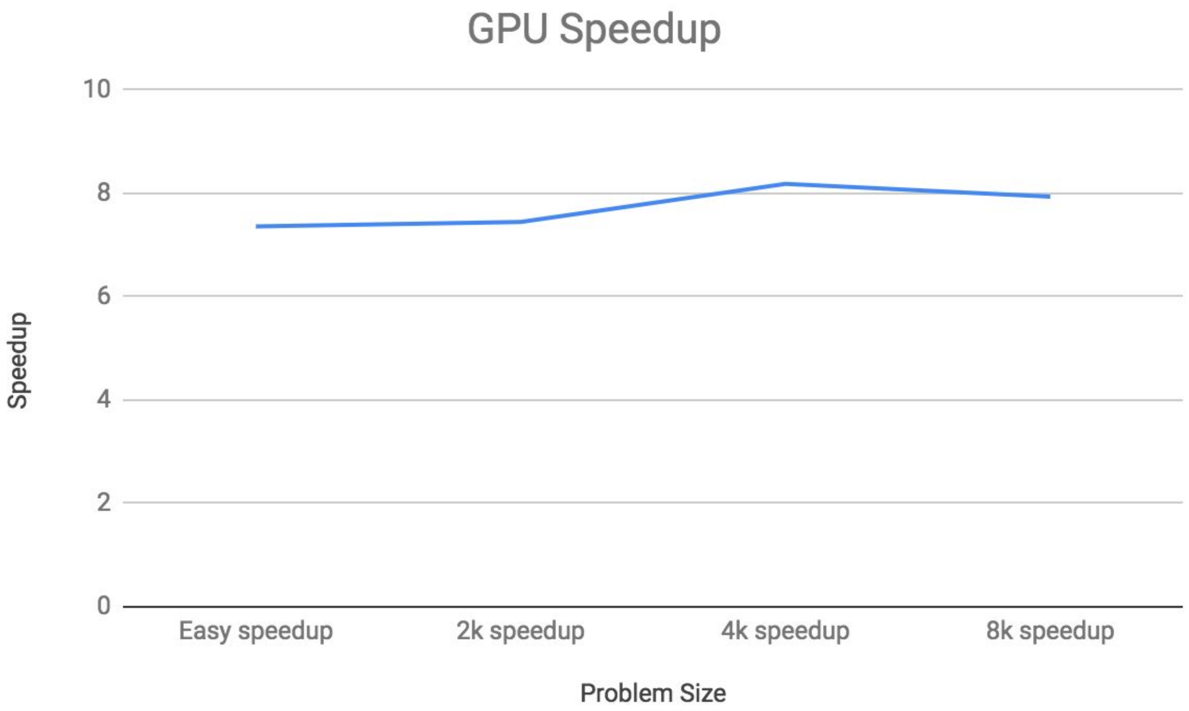


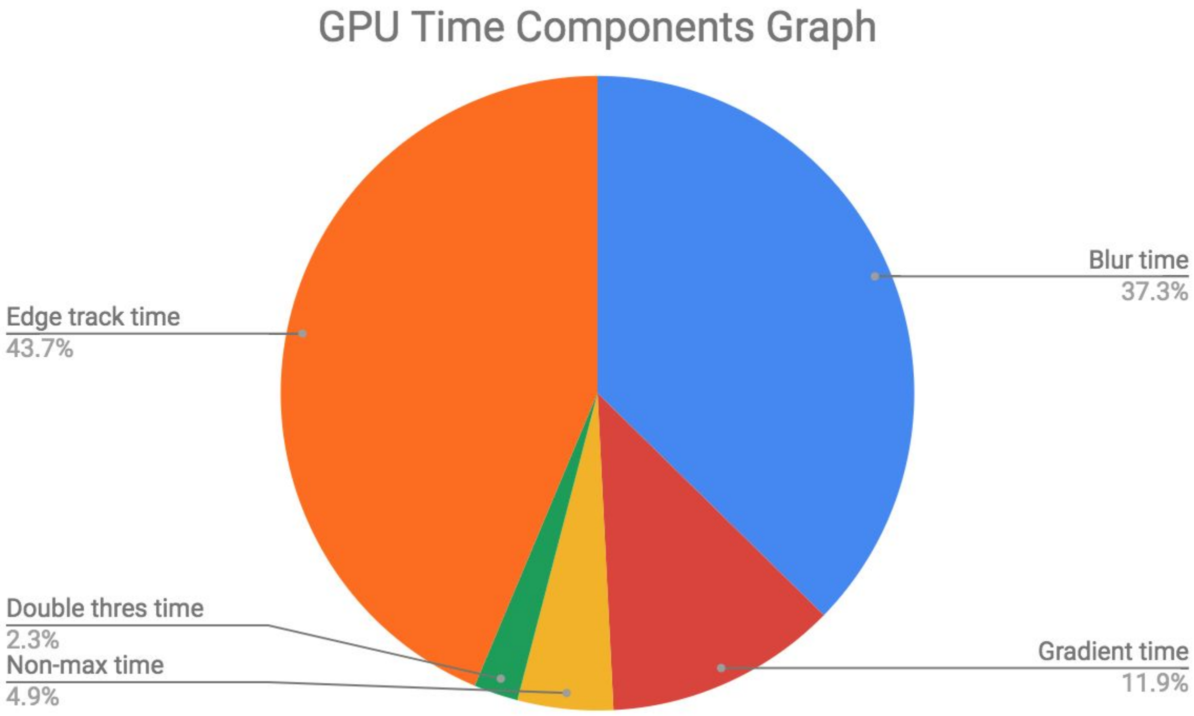
Step 3: Exchange connectivity results across border.

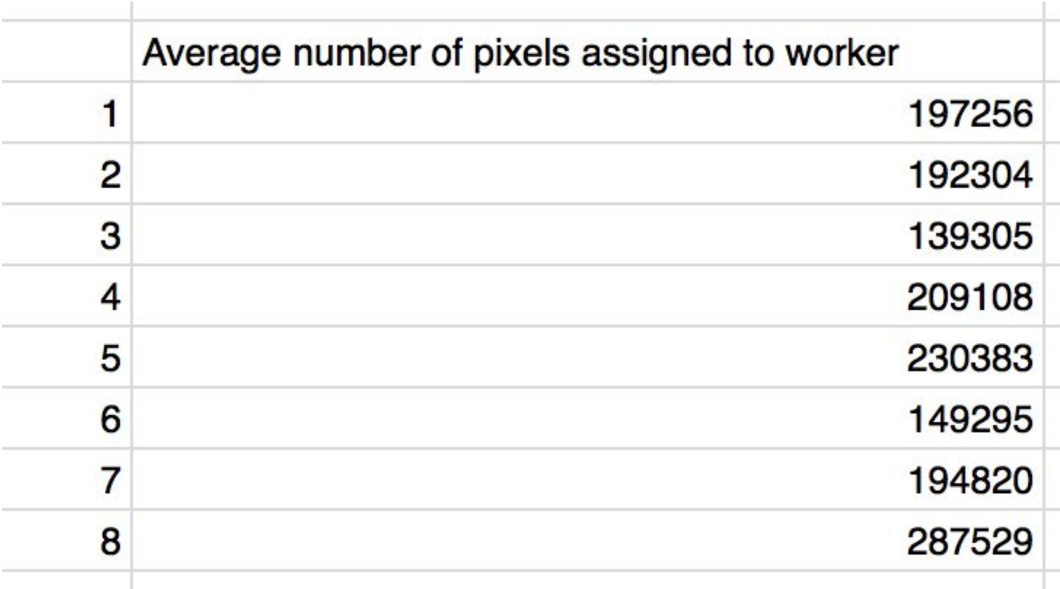
Repeat Step 2 and 3 for a fixed number of iterations.


CPU Speedup
Easy speedup
2k speedup
4k speedup
8k speedup
8
6
4
2
0
Speedup
1
2
4
8
16
Number of Processors


CPU Time Components
Blur speedup
Gradient speedup
Non-max speedup
Double thres speedup
Edge track speedup
8
6
4
2
0
Speedup
1
2
4
8
16
Number of Processors


GPU Speedup
10
8
6
4
2
0
Speedup
Easy speedup
2k speedup
4k speedup
8k speedup
Problem Size


GPU Time Components Graph
Blur time
37.3%
Edge track time
43.7%
Double thres time
2.3%
Non-max time
4.9%
Gradient time
11.9%



	Average number of pixels assigned to worker
1	197256
2	192304
3	139305
4	209108
5	230383
6	149295
7	194820
8	287529

GPU Speedup: 8

GPU limitations:

- Memory bandwidth in Gaussian filter and gradient calculation.
- SIMD Utilization in DFS

CPU Speedup: 6-7

CPU limitations:

- Work Imbalance when workload is small.
- Dynamic scheduling cost when workload is small.