LITERATURE REVIEW: — Your Project Title —

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1 Introduction

Introduce your project topic (start from parallel computing in general and lead to your particular topic). Describe what you intend to achieve in your project.

2 Literature Review

2.1 Edge Detection

Edge detection is a collection of mathematical methods which attempt to take in a digital image and identify the edges existing within it. The field originally started a long time ago, with one of the first papers coming out in 1965 [20], but this area of research is still active as the concepts used here are the foundation for many other fields - especially computer vision.

On a basic level, edge detection attempts to look for significant local change in image intensity. Discontinuities are either step discontinuities, or line discontinuities. The former is when we change rapidly from one value to another when going other a discontinuity. The latter involves the intensity of the image to change rapidly to a new value at some point, but then further down return to the same value [12, 13]. Unfortunately, real world images are often not as simple. Step edges turn into ramp edges and line edges become roof edges, with the changes of value occurring over a finite distance rather than abruptly [12]. Figure 1 demonstrates these differences.

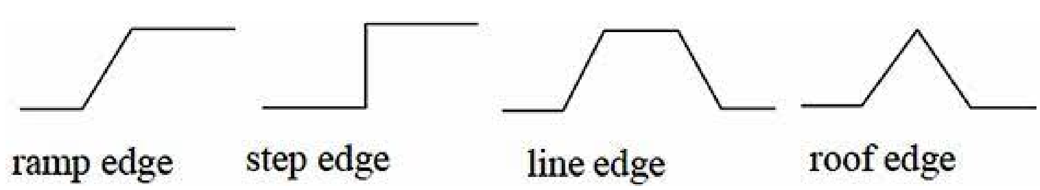

Figure 1: Examples of the four edge types

Edge detection algorithms attempt to detect significant local change in the image, while not letting the noise of the image get in the way. They quantify the image as an array of image intensity based on a continuous function [4, 23, 20, 19]. Commonly, a step edge would be associated with a local peak in the first derivative of the graph mapping values to location [12]. However, this results in too many edge points. The solution is to find points that have local maxima in gradient values and consider them edge points. The two main approaches here are the Laplacian and second directional derivative. We will now explore the main operators used in edge detection, both the first order and second order.

2.1.1 Roberts Cross Operator

One of the first edge detection operators proposed, the Roberts cross operator utilises discrete differentiation to approximate the gradient. It first applies the Gx and Gy mask, which are 2x2, to the entire image from where it proceeds to calculate the gradient magnitude [20].

+1	0
0	-1

Gx

0	+1
-1	0

Gy

Figure 2: Roberts Operator Kernel

2.1.2 Sobel Edge Detection

This was the next main edge detection algorithm to come out, and one that is still prominently in use today. The Sobel operator uses a 3x3 image mask to convolute the image, using horizontal and vertical anchoring. The masks allow approximation in both the y and x direction, from where it can more accurately estimate the gradient[23].

-1	0	+1
-2	0	+2
-1	0	+1

Gx

+1	+2	+1
0	0	0
-1	-2	-1

Gy

Figure 3: Sobel Operator Kernel

2.1.3 Prewitt Edge Detection

The Prewitt algorithm utilises a similar approach to the Sobel, however, it provided a slight computation speed improvement and also involves different kernels [19]. Note how the masks used for convolution do not place emphasis on the middle pixels as the Sobel kernels do.

-1	0	+1
-1	0	+1
-1	0	+1

Gx

+1	+1	+1
0	0	0
-1	-1	-1

Gy

Figure 4: Prewitt Operator Kernel

2.1.4 Canny Edge Detection

The algorithm proposed by Canny et al. is a computationally effective algorithm that declares computational requirements for edge detection and proposes a highly effective circular operator meant to work on any scale [4].

2.1.5 Laplacian Edge Detection

Laplacian edge detection involves the estimation of the second derivative. The first step involves the use of a Gaussian filter to blur the image, making it smoother to work with. From there masks are used to create the resulting edge images (with various kernels being able to be used) but the kernels are meant to calculate the second order derivatives. One thing to note is that since we have one kernel with the Laplacian, it computers the result much faster. However, because it uses second derivatives, it is extremely sensitive to noise [12].

0	–1	0
–1	4	–1
0	–1	0

Figure 5: Laplacian Operator Kernel

2.2 Overall Edge Detection

The above mentioned operators are the ones most commonly used in current industry and academia[27]. The authors would like to mention other notable papers that have not made it into a section of their own, yet these papers have also provided effective algorithms yielding quality results [3, 8, 18, 9, 13]

2.3 Edge Detection Improvement

2.3.1 Algorithmic

One attempted approach in literature is to improve the problem of edge detection utilising improved algorithms. Dollar et al. attempt to obtain edge detection improvement through the use of effective algorithmic structure. Their approach is to implement a structured decision forest, which improves runtime, but at the cost of having a lower accuracy[6]. Other approaches have also been taken in academia, with the majority having a pattern of improving the runtime of the algorithms, but at the cost of the quality of output [14, 26, 15, 25, 7, 1] Some of these papers directly attempt to alter the main existing algorithms, such as the Canny or Sobel, while others attempt to alter the way the operators are utilised. Another algorithmic improvement carried out by Rosenfeld and Thurston [21] introduced smoothing operations in order to reduce the noise of the image prior to differentiation, thus improving the edge quality. Another approach carried out by Hueckel [10, 11] involved fitting each image pixel with a step edge in a circular window. If the fit was accurate, it was safe to assume that an edge exists with the same parameters as the fitted model. This is called parametric fitting and has been attempted by other researchers as well, with varying success [5, 17, 16, 2]. Another approach taken is by changing the implementation side [22, 24].

2.3.2 Parallelism

- This section is currently unfinished but will discuss the research that exists to improve edge detection through the use of parallelism
- It will also be the section that proceeds to link my research to the current research, as I will be carrying out a verification of the work done in parallelism

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