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Hardware Unit for Edge Detection with Comparative Analysis of Different Edge Detection Approaches

[1]Kalpana N.Hajgude, [2] Mr. Shinde S.G.

TPCT'S College of Engineering Osmanabad, Maharashtra, India

Abstract: **An edge in an image is a contour across which the brightness of the image changes abruptly. In image processing, an edge is often interpreted as one class of singularities. Edge detection is an important task in image processing. It is a main tool in pattern recognition, image segmentation, and scene analysis. An edge detector is basically a high pass filter that can be applied to extract the edge points in an image. This topic has attracted many researchers and many achievements have been made. Many researchers provided different approaches based on mathematical calculations which some of them are either robust or cost effective. A new algorithm will be proposed to detect the edges of image with increased robustness and throughput. Using this algorithm we will reduce the time complexity problem which is faced by previous algorithm. We will also propose hardware unit for proposed algorithm which will reduce the area, power and speed problem. We will compare our proposed algorithm with previous approach. For image quality measurement we will use some scientific parameters those are PSNR, SSIM, FSIM. Implementation of proposed algorithm will be done by Matlab and hardware implementation will be done by using of Verilog on Xilinx 14.1 simulator. Verification will be done on Model sim.**

Keywords: **edge, robustness, time complexity, area, power, speed, mat lab.**

I. INTRODUCTION

Edge detection is the name for a set of mathematical methods which aim at identifying points in a digital image at which the image brightness changes sharply or, more formally, has discontinuities. Edges can be created by shadows, texture, geometry, and so forth. Edge points are to be associated with the boundaries of objects and other kinds of changes. Edges within an image generally occur at various resolutions or scales and represent transitions of different degree, or gradient levels. There are many ways to perform edge detection. However, most of them may be grouped into two categories, namely, gradient based edge detection and Laplacian-based edge detection.

In the gradient based edge detection, we calculate an estimate of the gradient magnitude using the smoothing filter and use the calculated estimate to determine the position of the edges. In other words the gradient method detects the edges by looking for the maximum and minimum in the first derivative of the image. In the Laplacian method we calculate the second derivative of the signal and the derivative magnitude is maximum when second derivative is zero. In short, Laplacian method searches for zero crossings in the second derivative of the image to find edges. Most image-processing techniques involve treating the image as a two-dimensional signal and applying standard signal-processing techniques to it. Image processing usually refers to digital image processing, but optical and analog image processing also are possible. An image defined in the "real world" is considered to be a function of two real variables, for example, a(x,y) with a as the amplitude (e.g. brightness) of the image at the real coordinate position (x,y).Modern digital technology has made it possible to manipulate multi-dimensional signals with systems that range from simple digital circuits to advanced parallel computers. The goal of this manipulation can be divided into three categories:

1. Image processing (image in -> image out)

2. Image Analysis (image in -> measurements out)

3. Image Understanding (image in -> high-level description out)

In the discussions that follow, the word derivative will refer to a spatial derivative of image pixel color value, unless otherwise specialized. There are many ways to perform edge detection. However, the majority of different methods may be grouped into two categories Gradient: The gradient method detects the edges by looking for the maxima and minima in the first spatial derivative of the image. Mathematically, the gradient of a two-variable function (here the image intensity function) at each image point is a 2D vector with the components given by the derivatives in the horizontal and vertical directions. At each image point, the gradient vector points in the direction of largest possible intensity increase, and the length of the gradient vector corresponds to the rate of change in that direction. Partial derivative towards x and y direction of the pixels (intensity values) are calculated first by applying an operator. Then gradient valued f (x; y) is calculated from these partial derivatives. Clearly, the derivative shows a maximum located at the center of the edge in the original signal. This method of locating an edge is characteristic of the 'gradient filter' family of edge detection filters and includes the Sobel method. A pixel location is declared an edge location if the value of the gradient exceeds some threshold. The original image can be easily restored from its edge map.

Various edge detection algorithms have been developed in the process of finding the perfect edge detector. Some of the edge detection operators that are discussed in this thesis are Robert, Prewitt, Sobel, FreiChen and Laplacian Of Gaussian (LOG) operators. Prewitt, Sobel and FreiChen are 3x3 masks operators. The Prewitt masks are simpler to implement than the Sobel masks, but the later have slightly superior noise suppression characteristics. LOG is a more complicated edge detector than the previous mentioned operators.

II. LITERATURE REVIEW

1. According to [1],[3],[8] author presents hardware structure of the sobel smooth filter. According to [1] The proposed Sobel edge detection operator is model using of Finite State Machine (FSM) which executes a matrix area gradient operation to determine the level of variance through different of pixels In this paper author used the old Sobel edge detection concept. Drawback of this paper is This paper I present old existing approach in hardware form there is no any novelty as algorithm form. Due to using of old approach there is large hardware unit is require.

2. According to [3] author presents a kind of parallel processing construction of Sobel edge detection enhancement algorithmIn this paper author used the old Sobel edge detection concept. In this work author use in the place of square unit he used absolute technique which will reduce some amount of timing and hardware complexity. Drawback of these approach is also present modified old existing approach in hardware. Due to using of modified old approach there is still large hardware unit is require. In [8] author presents In this work author proposed a new approach for detection of edge on noisy image. In this work they combine sobel edge detection and WAVELET THRESHOLD DE-NOISING approach. But drawback of these approach is due to combination of two approach there is large hardware unit with height time complexity is require

a) Motivation:

As we know in this era every mobile devices are using multimedia application.

1. Edge detection is main part for most of the multimedia applications.

2. As we know in present era there is trade of development of application specific processor so that why there is need of hardware unit of edge detection.

3. Present edge detection approaches are not good for hardware model because at algorithm level it will require timing complexity problem.

b) Research Gap:

1. Present different kind of canny and sobel edge detection approach is having the main problem of timing complexity.

2. Present different kind of canny and sobel edge detection is also not make any justice with SPAA metrics(Speed, Power, Area and Accuracy).
3. Present different kind of canny and sobel edge detection approach have the complexity of large hardware unit.

c) Thesis Objective:

1. Implement a fast edge detection algorithm based on basic sobel concept.
2. Design a fast hardware unit which will reduce time complexity issues.
3. Design a SPAA aware Edge detection unit which will make justice with SPAA metrics.

III. PROPOSED METHODOLOGY

The methodology consists of two stages

1. Algorithm stage:

As we know edge detection is very usefull application in graphics wolrd. As we already see there is different kind of problem is faced by previous edge detection approach. So for reduction of those problem here we will proposed a new Sobel edge detection technique. According to this technique we follow old sobel approach but here we will change the vertical and horizontal mask. Here we will proposed a plus mask logic. According to that approach for horizontal we will use only two pixel value and for vertical again we use only two pixel.

The main assumption of masking is made by considering the concept of inter pixel correlation. The pixel values in an image are very close to each other and the variation is almost equal to one. Instead of processing the entire pixel in 3*3 kernels, a suitable mask is applied as a filter which passes horizontal and vertical pixels as shown in below figure.

Proposed Horizontal Mask=

$$Gx = \begin{bmatrix} 0 & 0 & 0 \\ -2 & 0 & +2 \\ 0 & 0 & 0 \end{bmatrix}$$

Proposed Vertical Mask=

$$Gy = \begin{bmatrix} 0 & +2 & 0 \\ 0 & 0 & 0 \\ 0 & -2 & 0 \end{bmatrix}$$

Gx1=Absolute (Gx)

Gy1=Absolute (Gy)

Sobel Edge Pixel = Gx1+Gy1

Generated filter mask consists of few values which are to be processed which results in fast computation and low area and power consumption at architectural level. The new filter mask consists of negative and positive values. By applying absolute on the result values and summing up them generates the same conventional function with reduces complexity.

2 Architectural stage:

Our proposed architecture is an optimization novel architecture]. The Sobel instance is the basic building block of the Sobel processor and it is able to produce one output pixel. The instances are connected in a way that form one big combinational Sobel block that will exploit FPGA parallelism and I/O capabilities. The processor is multiplier free that avoids multiplication by one and replaces the multiplication by two with a shifting operation. Hence, the processor based only on simple additions, subtractions, shift registers and modulus operators. Here we implement our proposed architecture by using of Verilog HDL. Here we will also devlope a verification code using verilog only where we insert raw image in form of hex vaule and it will produce edge image as a from on of hex file.

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Fig.1.Top Module of our proposed Architecture

IV. RESULTS AND DISCUSSION

A new algorithm will be proposed and that algorithm will be implemented by using of MATLAb, for image quality measurement I will use some scientific parameters like PSNR, SSIM, FSIM. I will also propose hardware unit for my proposed algorithm which will reduce the area, power and speed problem. I will compare my proposed algorithm with previous approach hardware implementation will be done by using of Verilog on Xilinx 14.1 simulator. Verification will be done on Model sim.

a) Implementation of Proposed Sobel Edge detection: As we already discussed about our proposed edge detection. So here we will implement proposed architecture using of verilog and all simulation will be perform of xilinx 14.2. In this proposed approach we will proposed a multiplier less architecture and as compare to previous approach. In our design there is only need of four pixel which is able to generate edge based image.

b) Hardware Implementation: Proposed algorithm will also propose a novel hardware unit with using of Verilog HDL.

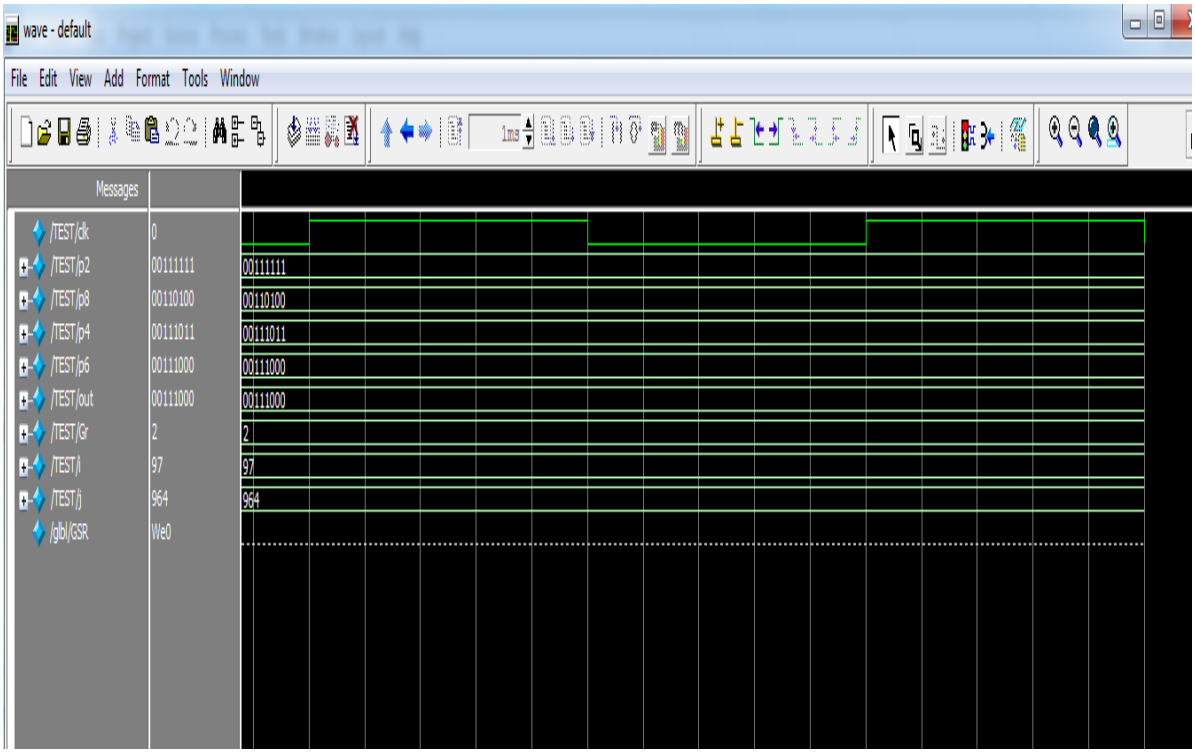

Fig.2. Simulation Result of Proposed Sobel Edge Detection

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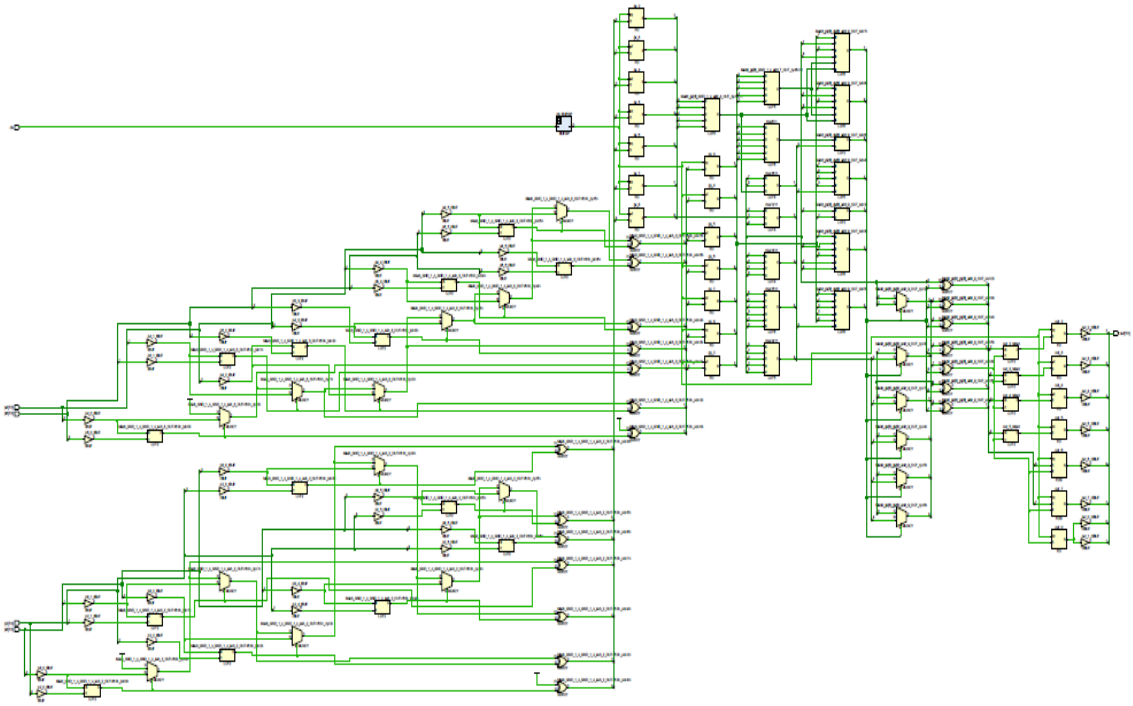
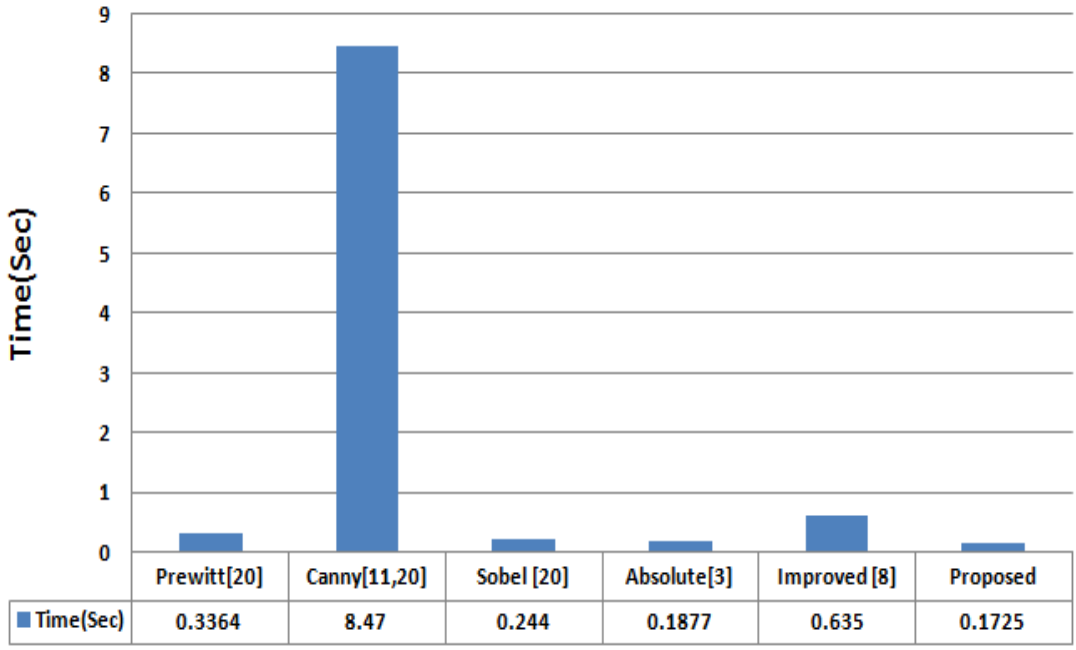


Fig.3. Detailed Proposed Schematic

Table 1.Time Complexity Analysis:

Parameter	Prewitt[20]	Canny[11,20]	Sobel [20]	Absolute[3]	Improved [8]	Proposed
Time(Sec)	0.336	8.47	0.244	0.188	0.635	0.173



Graph.1.Time and parameter

V. CONCLUSION

The key contribution of this work is to develop a fast Edge detection algorithm. Using this work we will develop a SPAA aware error tolerant Edge detection Unit. This proposed edge detection unit will require less area, power and speed. In this approach I will propose a new approach of approximation which will reduce some amount of accuracy. In proposed approach I will use only 4 pixel. Using this approach I will expect that it will reduce the timing complexity and hardware complexity with 30-40%.

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