

## **A Review on Edge Detection Techniques Based on FPGA**

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**ABSTRACT:** Edge detection of the image is one of the most fundamental features in image processing as well as in video processing. Edge detection of the image refers to the process of identifying, locating and indicating the discontinuities in image. Edge detection of the medical image is a very useful task for object recognition of human organs. The discontinuities are sharply changed in the pixel intensity. The software implementation for image processing algorithm is slower due to the limited processor speed so, the processor which is used for edge detection requires an advance VLSI technology. In this paper, FPGA based architecture of edge detection using prewitt, Robert, LOG, sobel operator and canny edge detection is discussed.

**KEY WORDS:** Image processing; Edge detection; Robert operator; prewitt operator; sobel operator; canny algorithm; FPGA

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### **I. INTRODUCTION**

Images edge detection is an important work for object recognition of the human organs, and it is an essential pre-processing step in image segmentation. Edge is defined as the boundary between two regions with relatively different gray level properties. An edge is a set of connected pixels that appear on the boundary between two regions. The edge detection of an image is a terminology in image processing, especially in the areas of feature extraction, to refer to algorithms which aim at identifying point in digital image at which the image brightness changes abruptly. The data of edge detection is very large, so the speed of image processing is a difficult problem. FPGA can overcome it.

The main objective of image processing is to improve the quality of the images for human interpretation or the perception of the machines independent of the images for human interpretation or the perception of the machines only. In the proposed system, sobel operator and canny edge detector are using for edge detection of medical images.

### **II. EDGE DETECTION**

Digital image processing method is used into a lot of application like geography and medicine. An image is a projection of a 3D scene representation into 2D scene. Edge is basically sharply changed in the intensity level of the digital image. Edge detection is one of the key steps in image processing, image pattern recognition and image analysis and computer vision methods. Edge detection techniques are followed by linking and boundary detection process. Edge detection is used to detecting discontinuities in gray level input image. There are so many methods are developing for edge detection. Few of them are reviewed in this paper. These techniques are given below:

- Robert operator
- Prewitt operator
- Sobel operator
- Laplacian of Gaussian
- Canny edge detection

### III. ROBERT OPERATOR

Robert operator is a first order derivative operator, which uses partial derivative operator for edge detection. Robert operator is most basic method for edge detection. It uses  $2 \times 2$  mask to finding the orthogonal derivatives. The gradient is not shifted by half-a-pixel in both directions. That's why the Robert operator is more sensitive with noise compare to the other edge detection methods. To speed up calculation, the edge magnitude is carried out as the absolute values of orthogonal derivatives [8].

In fig.1 derivative masks are shown for Robert operator. This derivative masks are compute the detector calculates derivatives along the diagonals.

1	0
0	-1

(a)

0	1
-1	0

(b)

Fig. 1 Derivative masks [8]

The Robert operator calculates the intensity variation along diagonals, that is, it carried out orthogonal derivatives.

### IV. PREWITT OPERATOR

The prewitt operator is used in image processing, especially within edge detection algorithm. At every point in the image, the output of the prewitt operator is either the representing gradient vector or the norm of this vector. The prewitt operator is carried out based on convolving the original with a separable, small and integer valued filter in horizontal, vertical as well as in both diagonals direction. The prewitt operator is also first order derivative operator.

The masks for edge detection are shown below:

1	0	-1
1	0	-1
1	0	-1

(a)

1	1	1
0	0	0
-1	-1	-1

(b)

0	-1	-1
1	0	-1
1	1	0

(c)

1	1	0
1	0	-1
0	-1	-1

(d)

Fig. 2 prewitt edge detection kernel [8]

Figure 3 (a) shows the kernel used to detect the vertical edge. Figure 3 (b) shows the kernel used to detect the horizontal edge. Figure 3 (c) and figure 3 (d) are used to detect two diagonals direction.

Prewitt operator is also called derivative operator or derivative mask.

### V. SOBEL EDGE DETECTION

The sobel operator is a classical first order edge detection operator, computing an approximation of the image intensity function. At the every point in the image, the result of the sobel operator is corresponding norm of this gradient vector. The sobel operator uses two 3×3 mask which are convolved with original image and calculate approximation of the gradient. These two convolution masks are design to detect the edge in horizontal and vertical direction. Figure 1 Shown the two masks  $G_x$  and  $G_y$ .



Fig. 3 Gradient masks <sup>[8]</sup>

The mask can be applied separately to the input medical image, to produce separate measurements of the gradient component in each orientation(suppose  $G_x$  and  $G_y$ ).These separate output gradient then combine together to find the absolute magnitude of the gradient at each and every point in image. The gradient magnitude is given by:

$$|G| = \sqrt{G_x^2 + G_y^2} \quad (1)$$

Using this information we can calculate the gradient direction.

$$\theta = \text{atan} \left( \frac{G_x}{G_y} \right) \quad (2)$$

$\theta$  is 0 for a vertical edge which is darker on the right side

### VI. LAPLACIAN OF GAUSSIAN

The Laplacian of Gaussian operator for edge detection was a very popular edge operator before canny algorithm is developed. The LOG is a gradient based operator which uses the Laplacian to take the second derivative of an image. The idea is that if there is a step difference in the intensity of the image, it will be represented by in the second derivative by a zero crossing

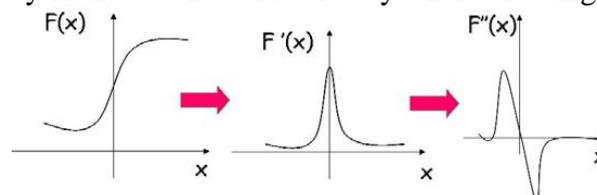


Fig. 4 Laplacian of Gaussian <sup>[15]</sup>

The general algorithm for the Laplacian of Gaussian edge detector is as follows:

1. Smooth the image using a Gaussian. This smoothing reduces the amount of error found due to noise.
2. Apply a two dimensional Laplacian to the image:

$$\nabla^2 f = \frac{d^2 f}{dx^2} + \frac{d^2 f}{dy^2} \quad (3)$$

3. Loop through with every pixel in the Laplacian of the smoothed image and check for sign changes. If there is a sign change and the slope across this sign change is greater than some threshold, mark this pixel as an edge. Alternatively, you can run these changes in slope through a hysteresis rather than using a simple threshold

## VII. CANNY EDGE DETECTOR

The canny algorithm was developed to detect the optimal edge detection. Optimal means it provide good detection capabilities, good localization and minimal response. Canny algorithm is generally based on three basic objectives. The first objective is low error rate i.e detected edge must be as close as possible to the true edge. The second objective is the edge should be well localized. The third objective is single point response i.e. Single response is obtained to single edge. The following are the various steps for canny edge detector algorithm:

### Noise Reduction

The first stage of canny edge detector involves smoothing the image by first derivative of the Gaussian filter. So, we get smooth image.

### Intensity Gradient

In this stage compute the gradient magnitude and angle images. Since an edge in the image may point in variety of direction, vertical, horizontal and diagonal edge to be detected. This is done by calculating the gradient of the neighborhood pixel.

### Non Maximum Suppression

The non-maximum suppression stage obtains the local maxima in direction of the gradient, and suppresses the all other direction, minimize the false edges. The local maxima are found by comparing the pixel with its neighborhood pixel along the gradient direction.

### Thresholds

The method for thresholding in canny edge detection is referred as “hysteresis”. It makes both a high threshold and a low threshold. The pixel value above high threshold is indicating as the edge of the pixel. The pixel value above the low threshold and its neighbor pixel is edge pixel, it also refer as the edge pixel as well.

## VIII. FPGA

In the recent year, Field programmable Gate arrays have become the dominant kind of programmable logic device. FPGA can implement too much larger logic function compare with previously programmable device like PAL (Programmable Array Logic) and CPLD (complicated programmable logic device). FPGA could be a very large scale integrated circuit which will be re-

programmed. FPGA provides designers with reconfigurable logic that can be reprogrammed as per the user requirement. This ability in FPGA increases flexibility in the event of image processing algorithm on FPGA. The special potential of the FPGA is parallel processing and high computational density as compared to the general purpose microprocessor. This step is combining together with the capacity of FPGA being re-programmable and because this reason FPGA become the dominant form of the programmable logic device which play a useful role for implementation of image processing algorithms.

### IX.RESULT ANALYSIS BASED ON FPGA

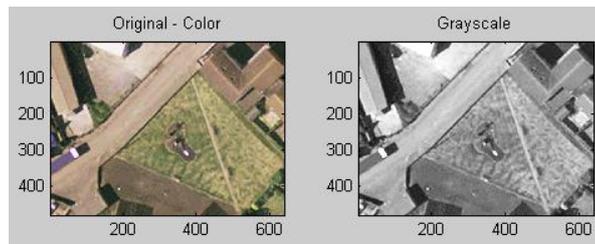


Fig. 5 original image [6]

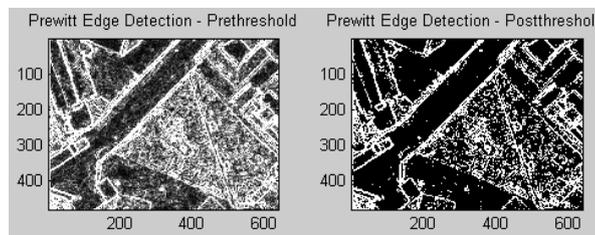


Fig. 6 Edge detected image using prewitt operator [6]

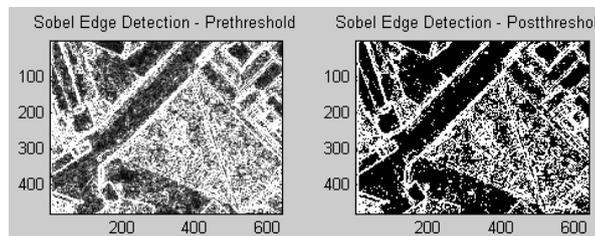


Fig. 7 Edge detection using sobel operator [6]



Fig.7 Original and edge detected fruit image using canny edge detector [7]

Fig 5, 6,7 indicate the original image, edge detected image using prewitt operator and edge detected image using sobel operator respectively. Fig. 7 indicates original and edge detected fruit image using canny edge detector. This all results are implemented on the FPGA kit individually.

## **X.LITERATURE SURVEY**

- 1. Manel Elloumi, mohamed Krid, dorra sellami masmoiydi [1]** presented Neuro fuzzy system based edge detection of the digital image.
- 2. Sanjay singh, Chandra shekhar [2]** presented the technique optimized VLSI architecture for color edge detection using sobel operator is designed and implemented on virtex-5 FPGA platform
- 3. I.Yasri, N.H hamid [3]** presented sobel edge detection operator is model using finite state machine (FSM). The whole procedure is implemented on FPGA with 27 MHz clock period.
- 4. Dina Alghurair, Sefwan S. Al-Rawi [4]** presented edge detection using sobel operator and implement it on different FPGA kit i.e. spartan3, spartan6, virtex5 and virtex6.
- 5. JIANG Xingfang, BI Tianyu, TAO chunkan [5]** presented edge detection based on wavlet transforms. The program that was the improved wavelet transform in the code compose studio language programming environment.
- 6. R. Harinarayan, R. pannerselvam, M. Mubarak Ali, Dhirendra kumar tripathi [6]** describe the architecture can be used as a building block of an aerial imaging system for navigation and for the pattern recognition [6]. The techniques used for edge detection in this paper are sobel operator and prewitt operator and implemented it on FPGA.
- 7. Qian Xu, Srenivas Varadarajan, Chaitali Chakrabarti And Lina J. Karam [7]** describe a technique to carry out the canny algorithm at the block level without any loss in the edge detection performance compared to the original frame-level canny algorithm. A distributed canny edge detection algorithm is used which adaptively compute the edge detection thresholds based on the block type.

## **XI.CONCLUSION**

In this paper, the different techniques for edge detection based on FPGA are reviewed and focus has been made on detecting the edge of image. The FPGA based architecture reduced time for edge detection and give the real-time edge detection of image. The complexity in the canny edge detector is high compare with other detector. The sobel and prewitt operator are similar in terms of speed. Compare to prewitt operator the sobel operators can save mostly of the high-frequency information of the image. The sobel edge detection technique has less sensitive in terms of noise. The sobel operator detects the thicker edge. Neuro fuzzy based edge detection reduced the response time compare with other device.

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