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Review Article

A REVIEW PAPER ON DIFFERENT EXISTING EDGE DETECTION TECHNIQUES

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ABSTRACT

Edge detection plays a major role in image processing. The objective of edge detection is to discard unimportant and unnecessary events and preserve the essential informations. It is the main tool of pattern recognition, image segmentation, and analysis of scenes. Edge detectors are used to remove the edge points in an image. Edge detection has attracted many researchers. Over the years many researchers have contributed to the field of edge detection. It is one of the techniques for detection of intensity discontinuities in a digital image. This paper presents a review on different edge detection techniques like prewitt, robert, sobel and LOG (Laplacian of Gaussian).It describes the comparative study on different existing edge detectionmethods.RGB is described in this paper. The paper also includes the description of the effect of noise on the RGB image and various techniques to detect the edges accurately.

KEYWORDS: Sobel, RGB, SPAA, FPGA

INTRODUCTION

Edge detection is a method that reduces the amount of data to be processed. It filters out the less relevant information and preserves the important structural properties of an image. It is basically a name given to a set of mathematical methods which aims at identification of the points which have discontinuities. In other words, we can say that it identifies the points where brightness of the image changes sharply. The points at which brightness of the image changes sharply are grouped into a set of curved line segments. These curved line segments are called edges. Edge detection is a fundamental tool of image processing, computer vision and machine vision, particularly in the areas of detection of features and feature extraction. [16, 17].The process of identification of sharp discontinuities in an image [18] and locating them is called edge detection.

Edge detection is sensitive to noise because the edge detection algorithms respond to sharp changes that can be caused by pixels with noise. In digital images, noise may occur for a number of reasons. The most common noises are white noise, speckle noise and salt &pepper noise. The discontinuities are sudden changes in the pixel intensity which characterizes the boundaries of the objects in a scene.

The classical methods of edge detection were based on convolution of image with an operator (2-D filter [5]) that is easily influenced by large gradients in the image. There are large numbers of edge detection operators. Each operator is sensitive to certain types of edges. There are various ways to perform edge detection. However the methods are grouped into two categories:

Gradient

For detection of the edges the gradient method looks for the minima and maxima in the first spatial derivative of an image. In mathematical way. we can say that the gradient of a two-variable function is a 2D vector at each image point. Here we are considering image intensity function as a two- variable function. The components are given by the derivatives in the horizontal and vertical directions. The gradient vector is directed in the path of largest intensity increase. The length of the gradient vector is same as that of the rate of change in that direction. The maxima is located at the center of the edge which is shown by the derivative. This form of locating the edges is the characteristics of the gradient filter family and includes the Sobel method. As edges will have higher pixel intensity value than those surrounding it, so firstly a threshold is set and then the gradient value can be compared to the threshold value .The edge is detected when the threshold is exceeded.

Laplacian method

Laplacian method [3] is also known as second order derivative. For detection of the edges it searches for zero crossing in the second derivative of the image. An edge has one dimensional shape of a ramp and calculation of the derivative of the image can emphasize its location. Also, the second order derivative is zero when the first order derivative is at maximum. As a result, location of edge can also be found by locating the zeros in the second order derivative. The second order derivative of an image can be obtained by applying a suitable operator.

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Robert's Cross Operator

The Robert's Cross operator [5] is a simple, quick to compute, convolution based operator for extraction of the edges. Pixel value of each point in the output represents the absolute magnitude of the spatial gradient of the input image that is estimated. This operator comprises of two 2x2 convolution kernels. These kernels are designed to respond to a maximum extent to the edges running at 45 degree to the pixel grid. The results of the operation will highlight the change in intensity in a diagonal direction. The most attractive aspect of this operation is its simplicity. The kernel is small. It contains only integers. However, because of the speed of computers this advantage is negligible nowadays and the Roberts cross suffers a lot from sensitivity to noise.

Sobel Operator

Sobel operator uses two 3x3 kernels. They are convolved with the original image. By rotating the first kernel by 90° the second kernel is obtained. These are orthogonal. The kernel values are designed so as to get maximum response to edges running in vertical and horizontal direction related to the pixel grid. The kernels are used separately by the input image in order to produce separate measurement of the gradient component (known as and Gy).Then these can be grouped together so that absolute magnitude and orientation of that gradient could be found. The angle of orientation of the edge that give rise to the spatial gradient is given by:

(1)

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

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

Fig 1: The convolution kernel for the Sobel Edge detector

The gradient magnitude is given by:

$$|G| = \sqrt{Gx^2 + Gy^2} \qquad (2)$$

An approximate magnitude is obtained using:

$$|G| = |Gx| + |Gy| \qquad (3)$$

The angle of orientation is given by:

$$\theta = \mathrm{ai} \qquad (4).$$

Prewitt Operator

Prewitt operator is akin to the Sobel operator and is used for detection of vertical and horizontal edges. At each point in the image, the output is the corresponding gradient vector .The result of all the three (Sobel, Robert's Cross and Prewitt) operators on an image point is a zero vector when it is in the area of constant image intensity. And when the image point is a point on an edge, then it is a vector which points across the edge, from darker to brighter values.

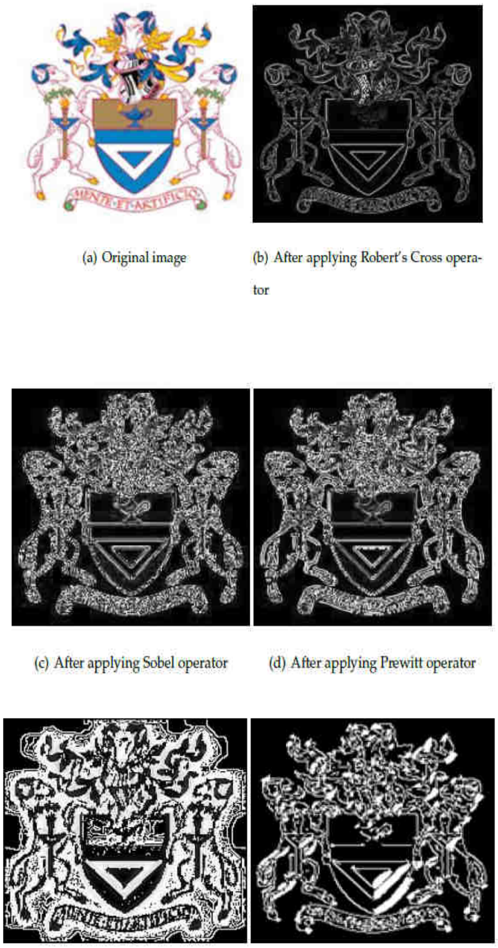
Laplacian of Gaussian Filter

The Laplace operator is also known as Laplacian method. It is a 2-D isotropic measure of the second spatial derivative of image [13] .The regions of rapid intensity change is highlighted by the Laplacian of an image .Thus it is often used for edge detection. Laplacian is usually applied to an image that has been smoothed out first in order to reduce the noise. Normally, a single gray level image is taken by the operator as input and another gray level image is produced as output.

Cranny's Edge Detection Algorithm

The Canny edge detection [11, 20] algorithm was developed for the improvement of the existing methods of edge detection. The first criterion is low error rate. Another criterion is that the edge points are localized in a well manner. The third criterion is to get only one response to a single edge. Based on the criteria mentioned above, the Canny edge detector eliminate the noise by smoothing the image first. It then finds the image gradient for highlighting the regions with high spatial derivatives. Then the pixel that is not at the maximum (non–maximum suppression) is suppressed by the algorithm. Now the gradient array is further reduced by hysteresis. In Canny edge detection two threshold values is followed. When magnitude is below first threshold, it is made a non–edge (set to zero).If the magnitude is above high threshold, it can be called as an edge. And if the magnitude is between the two threshold values, then it is fixed to zero unless there would be a path from the same pixel to a pixel with the gradient above the lower threshold value.

RGB RGB is a color model in which Red, Green, Blue light are added in different ways to reproduce a broad range of colors. The main purpose of RGB color model is to sense, represent and display images in electronic systems like televisions and computers.RGB has also been used in conventional photography.



(a) Original image (b) After applying Robert's Cross operator

(c) After applying Sobel operator (d) After applying Prewitt operator

(e) After applying LoG operator (f) After applying Canny method

Fig 2: Different Edge detection Methods applied on an image

LITERATURE REVIEW

Over the years many authors have contributed to the field of edge detection. Standard Sobel operator for a 3×3 neighborhood is a vector sum of a pair of orthogonal vectors. We can say that the orthogonal vector is a directional derivative estimate multiplied by a unit vector. It specifies the direction of the derivative. The vector sum of these simple gradient estimate amounts to a vector sum of 8 directional derivative vectors. In [7], *G* (directional derivative estimate vector) was defined as density difference distance to the neighbor. This vector is determined in such a manner that the direction of *G* is given by the unit vector of the approximate neighbor. The neighbors are grouped into antipodal pairs. Here, this vector is multiplied by 2. The resultant formula is given as follows (see, for detail [7]). One mask is the other rotated by 90°.These masks were designed to respond to a maximum extent to the edges running in vertical and horizontal direction related to the pixel grid. The dimension of the matrices were extended using [6]. The definition of the gradient can be used for a 5×5 neighborhood [8].In this case, instead of four gradients ,twelve directional gradients must be determined. The resultant vector *G'* (similar to the Sobel 3×3 method) for 5×5 is given as follows:

PSEUDO-CODES FOR SOBEL EDGE DETECTION

Input: A Sample Image.

Output: Detected Edges.

Step 1: Input image is accepted.

Step 2: Mask Gx, Gy is applied to the input image.

Step 3: Sobel edge detection algorithm and the gradient is applied.

Step 4:Masks manipulation of Gx, Gy is done separately on the input image.

Step 5:Results are combined and the absolute magnitude of the gradient is found.

Step 6: The output edge is the absolute magnitude.

How It Works

The operator consists two 3×3convolution kernels as shown in Figure 3.One kernel is rotated by 90°.This is similar to the Robert's Cross operator.

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

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

Fig 3: Sobel convolution kernels

The. kernels are designed to respond to a maximum extent to the edges running in vertical and horizontal direction related to the pixel grid. To produce separate measurements of the gradient components in each orientation, the kernels are applied separately to the input image.

P_1	P_2	P_3
P_4	P_5	P_6
P_7	P_8	P_9

Fig4: Pseudo-convolution kernels used to compute approximate gradient magnitude in a quick way

Using the kernel the approximate magnitude is given by:

$$|G|=|(P_1 + 2\times P_2 + P_3) - (P_7 + 2 \times) \quad | + |(P_3 + 2\times P_6 + P_9) - (P_1 + 2\times P \qquad (5)$$

a	b	c
d	e	f
g	h	i

Fig 5: The neighbors grouped into antipodal pairs

The directional derivative estimate vector G is defined such as density difference distance to the neighbor. This vector can be determined in such a way that the direction of *G* is given by the unit vector to the approximate neighbor. The neighbors are grouped into antipodal pairs as (a,i), (b,h), (c,g), (f,d). The vector sum for this gradient estimates:

G= + · +(b-h)·[0,1]+(f-d)·[1,0] (6)

where, R = .

This vector is obtained as follows:

$$G = [(c - g - a + i)/2 + f - d, (c - g + a - i)/2 + b -] \qquad (7)$$

Here, this vector is multiplied by 2.The resultant formula is given as below:

G'= =[(c-g-a+i)+2·(f-d),(c-g+a-i)+2·(b-h)] (8)

The weighting functions for x and y components obtained using the above vector are as follows:

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

1	0	1
-2	0	2
-1	0	1

It is elaborated that the dimensions of the matrices are tended by using [1]. The gradient definition can be used for 5×5 neighborhood[8].In this case, instead of four gradients twelve directional gradients must be determined.

The resultant vector *G'* for 5×5 is given as follows:

G'=[20(n-l)+10(i-r-g+t+o-k)+5(e-v-a+z)+4(d-w-b+y)+8(j-p-f+u),20(h-s)+10(i-r+g-t)+5.(e-v+a-z)+4(j-p+f-u)+8(d-w+b-y) (9)

Using the coefficients in this equation the horizontal and vertical masks could be obtained such as

-5	-4	0	4	5
-8	-10	0	10	8
-10	-20	0	20	10
-8	-10	0	10	8
-5	-4	0	4	5

5	8	10	8	5
4	10	20	10	4
0	0	0	0	0
-4	-10	-20	-10	-4
-5	-8	-10	-8	-5

Each direction of Sobel mask is applied to an image, and after that two new images are formed. The vertical response is shown by one image and the horizontal response by the other. Two images are combined into a single image so that determination of the existence and location of edges could be done. An algorithm was developed so that edge could be found by the use of new matrices and then a MATLAB function, which is called Sobel 5×5.m is implemented in MATLAB. This function needs a gray scale intensity image, two-dimensional array. The result that is obtained by this function is the final image. Here, white color represents the edge pixels. According to [5,17] author presents a new approach for sobel edge detection. According to [5] author presents a new approach for the detection of edge on a noisy image. Here combined sobel edge detection and Wavelet threshold denoising approach is used. But drawback of the approach is due to the combination of two approaches. Large hardware unit with high time complexity is required. Similarly according to [17] a novel colour edge detection algorithm is described. In this algorithm an improved Kuwahara filter was used.

RESEARCH GAP

Previous existing edge detection algorithms have many issues. Some approaches faced the issue of quality. The edges detected were not accurate enough. The edges detected were not very clear and tiny but meaningful changes were left undetected. Some approaches faced the issue of time complexity. The time taken by the algorithms to compute the edges were very large. Some of the approaches faced the issue of area complexity and power consumption. The power consumed was large. Some approaches were only based on greyscale images. Some were based on RGB images.

FUTURE SCOPE

In this paper the main motive is to improve previous existing issues. So the objective is to improve the time complexity. The time consumed by the algorithm will be minimized. The edges will be detected in less time. Thus computation speed will be increased. Also this paper elaborates that power consumption and the area complexity will be reduced and this increases the use in different applications.

APPLICATIONS

Edge detection is the basic tool for image segmentation, pattern recognition, scene analysis etc. In image processing, the edge detection helps in detection of physical and geometrical properties of the objects of the scene and also treats localization of important variations in gray level image. Edge detection has a major feature for image analysis. These features are used by the advanced computer vision algorithm. Edge detection is used for object detection which serves different applications in various areas.

CONCLUSIONS

Previously various approaches have been used to perform edge detection. Some used combined sobel edge detection and wavelet threshold de-noising. Some of them used Kuwahara filter for smoothing the original image. Some used canny edge detection and improved canny edge detection technique. But these methods faced many issues. Some faced the issue of quality; some faced the issue of time complexity and memory. Some algorithms were highly complex. Still there are many future scopes of edge detection.

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