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Evaluation and Comparative Study of Edge Detection Techniques

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Abstract: *In this paper edge detection technique is studied using image processing. In image analysis, edge detection is one of the most commonly and frequently used operation, and there are probably some more algorithms in the literature for enhancing and detecting edges. Edge detection is the method of pointing and detecting sharp discontinuities in an image. The gap or discontinuities are unexpected changes in the intensity of pixel which distinguish boundaries of objects in a images. Edges form the outline of an object which is the main reason behind boundaries of objects in a scene. An edge is a borderline between object and its background which means if detection of an edge can be done then the respective object can be found and properties like area, the perimeter can be measured. Since computer vision involves the identification and classification of objects in an image, edge detections are a fundamental and essential tool. Here, we have evaluated several techniques of edge detection with different images in image processing.*

Index Terms—*Computer vision, Edge detection, Image processing, Pixel.*

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I. Introduction

The edge detection methods has a significant role in image processing work. By using image processing, we can use computational power for variety of applications [6]. We can use edge detection techniques in different fields of industry and agriculture [16]. The purpose of edge detection is to point out the differences and to identify the physical occurrence which produces them. Image edge information contains a lot of information [4]. Edge detection must be convenient because the validity, competence, and probability of the completion of successive processing phase depends on it. The segregation of the image into the background and object is a critical step in the image interpretation. Edges are the boundary between different textures. Edge is the discontinuities in the image intensity from one pixel to another. Detection of the edges for an image may help for data compression, data segmentation, and image reconstruction [2]. Edge detection is difficult in the noisy image since both the noise and edge contain high-frequency contents. Attempt to reduce the noise results makes the image more noisy and result in distorted image. Filters are used in the process of identifying the images by pointing and locating the discontinuities which brings the changes into pixel intensity are the boundary of an image. We always need a good edges for higher level processing. An accurate and fast edge detector can upgrade the performance for complete processing system [19]. There are a lot of edge detection techniques available and each designed with a certain type of features. Since basic of image processing for object detection is edge detection, it is pivotal to have a good grasp of the edges detection techniques. In the fig. 1, the gradient vector of an edge pixel is shown. The intensity for each pixel changes from 0 to 255 in the gradient direction. strength of the edge is indicated by the magnitude of the gradient. An edge pixel is identified by using two traits, the edge strength which is the magnitude of the gradient, and the edge direction which is the angle of the gradient. [9].

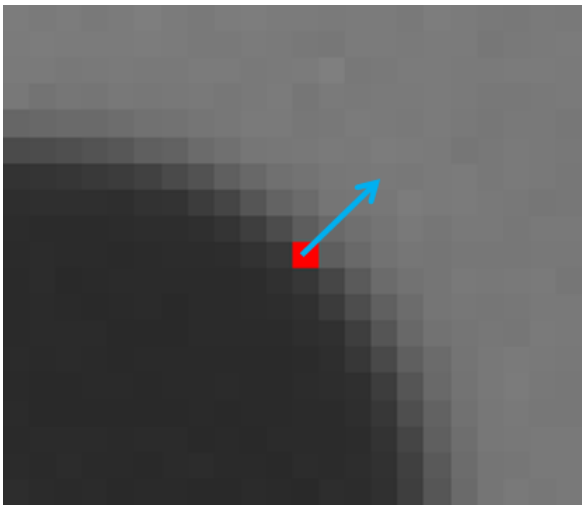

Fig. 1 The gradient of pixel of an image

The characteristic direction is determined by the geometry of the operator which is most sensitive to edges. Operators can be easily optimized to look for diagonal, vertical, or horizontal edges. There are many ways to perform edge detection, but the majority of the techniques can be classified into two groups:

· Gradient-based edge detection: The gradient method finds edge by looking for the maximum and minimum in the first derivative of the image.

· Laplacian based edge detection: The Laplacian method searches for zero crossings in the second derivative of the image [14-17]. An edge has the shape of a ramp which is one-dimensional and location can be easily highlighted by calculating the derivative of the image [11]. Assume we have the following signal, with an edge shown by the jump in intensity below:

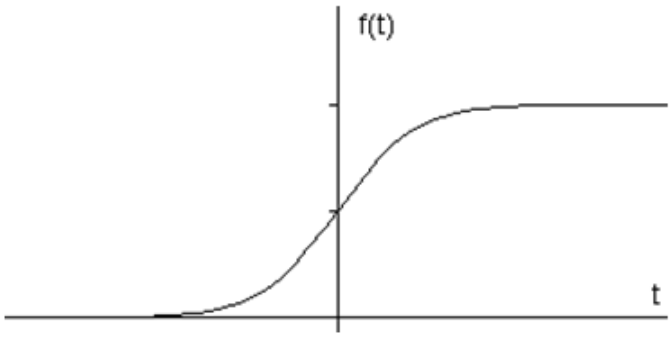

Fig.2 Intensity jump

If we consider the gradient of this signal (which, in one dimension, is just the first derivative concerning for to t) we get the following:

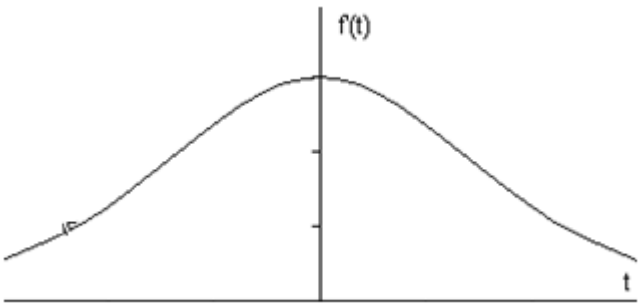

Fig.3 First derivative

II. Methodology

1. There are a lot of problems due to false edge detection, missing true edges, in edge detection techniques production of thick or thin lines are problems due to noise. The visual comparison is analyzed in this paper which is the most used Laplacian and Gradient-based Edge Detection techniques for problems of faulty edge detection, missing real edges, problems due to noise, and producing thick or thin lines, etc. In this paper, different edge detection algorithms are compared to find an efficient and superior edge detection algorithm. Different edge detection method

2.

2.1 Sobel operator

Sobel edge detection is considered a traditional method used in image processing techniques. The Sobel kernels are suitable to detect edges along the vertical and horizontal axis. The Sobel operator is based on convolving the image with a separable, small, and integer-valued filter [13]. The Sobel uses two pairs of 3x3 kernels for x and y-direction.

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

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

Table.1 x-direction Table.2 y-direction

the kernel is rotated by 90°. This method is used to calculate the gradient magnitude and direction of each image pixel. The magnitude of the vector is given as:

$\Delta f = mag(\Delta f) = [G_x^2+G_Y^2]^{½}$.....(1)

1.2 Prewitt edge detection

Prewitt edge method matches with Sobel edge method. Prewitt edge detection masks are one of the old and well-understood methods of detecting edges in images. It is widely used for detecting horizontal and vertical edges and gives those points where there is maximum gradient [12]. The strength of the edge at the given point is then the square root of the sum of the squares of two derivatives.

1.3 Canny edge detector

Canny edge detection detects a wide range of edges in image. It is a multi-step algorithm which can detect edges with noise suppressed at the time [5]. It was proposed to buy Canny in 1986. the initial level, it applies a Gaussian filter that smooths the image to wipe out the noise. The main problem with this type of edge detection approach is a high threshold misses important edges and a low threshold produces false.

1.4 Robert edge detection

This operator executes a gradient detection using the difference between adjacent pixels in the diagonal direction [3]. In Robert edge detection, the horizontal and vertical edges are calculated individually and then put together for resulting edge detection [18]. It approximates the gradient intensity in discrete differentiation, which is obtained by the summation of squares of differences between diagonally adjacent pixels. The Roberts edge detector computes 2-D spatial gradient on the image [8]. It uses a pair of 2x2 convoluted kernels, which is like a Sobel edge method. Roberts x, y kernels is mentioned below:

0	+1
-1	0

+1	0
0	1

Table.3 G_x Table.4 G_y

1.5 Laplacian of Gaussian (LOG)

This method of edge detection was invented in 1980 by Marr and Hildreth. In this method, the Laplacian is combined with Gaussian filtering change the image where the intensity varies to detect the edges effectively. It finds the actual place of edges and testing large area around the pixels. The disadvantage of the LOG operator is that it cannot find out the orientation of edge because of the Laplacian filter. The use of gaussian operator in LOG formulation is to smooth the image and use the zero crossing to the location of edges [7].

All of these techniques can be grouped into three modules

- Gradient (estimate of the 1stderivative)
- Laplacian (Zero crossing detectors) derivative)
- Image approximation algorithm

Edge Detection Categories	Existing Approaches
1st Order Derivative or Gradient method	Sobel, Prewitt, and Roberts Operator
2nd Order Derivative or Zero Crossing	LOG, Difference of Gaussian
Optimal method	Canny method

Table.5

3. Mathematical morphological operators

In a morphological operation, each and every pixel in the image is compared based on the value of other pixels in its area of neighbourhood [1]. A structuring element is a special filtering tool that enhances an input image. It can be of different sizes and different shapes. In mathematical morphology, a gradient image can be considered as a topological surface where the numerical value of each pixel indicates the evaluation of their points [10]. These are Some of the main mathematical morphological operators:

2.1 Dilation

It is the highest value in the window. The image after dilation becomes brighter or the intensity increases because of the maximum value in the window. It expands the image and is mainly used to fill the gap. Dilation process expands image objects by changing pixels with a value of "1" from"0".

2.2 Erosion

It is not at all similar to dilation. It is the lowest value in the window. The image after Erosion will be darker than the original image. It shrinks or thins the image. This process shrinking objects or images by changing pixels with a value of "1" to "0".

2.3 Opening and closing

Both opening and closing parameters are formed by using erosion and dilation. In the opening, firstly image will be eroded and then it will be followed by dilation. And in case of closing, firstly image will be dilated and then followed by erosion.

A. Mean Squared Error

The average of the squares of the "errors" is measured by the mean squared error of an estimator i.e. the difference between what is estimated and estimator. The contrast happens due to randomness or as a result of the estimator doesn't calculate information that could result in a better accurate estimate. The PSNR differ inversely with the MSE.

The mean square error is the squared error averaged over the M × N array.

$MSE=1/MN \sum \sum (f1(m,n)- f2(m,n))2$ ……(1) Where f1 (m, n) and f2 (m, n) are the output and input images respectively and M, N are the dimensions of the image. Its value must be less.

$RMSE=\sqrt{MSE}$

B. Peak signal to noise ratio

Peak signal to noise ratio is the ratio between the power of corrupting noise and the most significant possible power of a signal. It is represented by PSNR. Here, PSNR refers to the ratio between the edge detected images i.e. the estimator output and the ground truth image which is also referred to be the estimated image. It is the logarithmic function of the peak value of the image and the mean square error. Usually, PSNR is expressed in decibel scale. PSNR can be rated by the following Equation 2:

PSNR=10 LOG(2552/MSE) ……(2)

Where MSE is mean square error. Its value must be high.

Original images are shown below and algorithms are applied to it.

Fig. 3 image1

Fig. 4 image2

4. Algorithm For Edge Detection

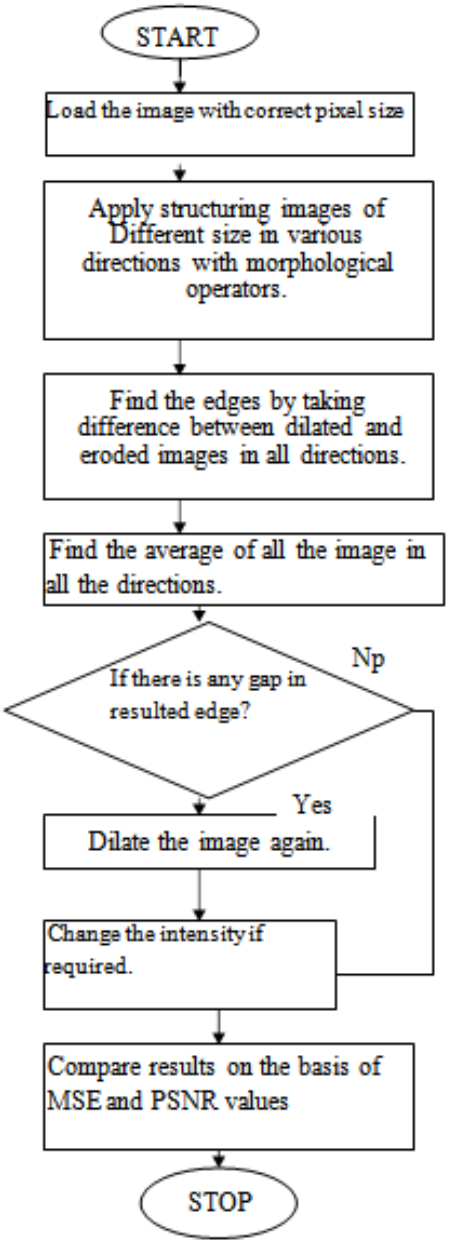

Fig. 5 Algorithm chart

5. Experimental Analysis

This section represents the analysis of the various method of edge detection techniques. All the experiments have been performed using Matlab and python programming. The experimental results of the images are obtained.

Fig 3.1 Robert image1

The above image is the result of Robert's operator of the image1.

Fig 3.2 Sobel image1

This is the Sobel operator form of image1.

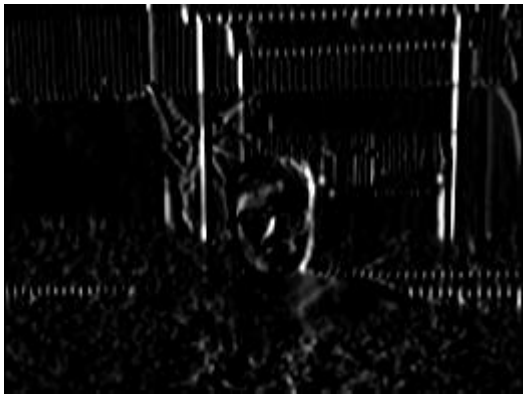

Fig 3.3 Prewitt image1

This is the Prewitt operator form of the image1.

Fig 3.4 Laplacian of gaussian image1

This image is obtained by the experimental analysis of the Laplacian of Gaussian operator of image1.

Fig 3.5 Canny image1

This is the most efficient and optimal method of edge detection. This is obtained by the experimental analysis of Canny edge detection operator of image1.

Fig 4.1 Robert image2

This image is obtained by the experimental analysis of Robert operator of the image2.

Fig4.2 Sobel image2
This is the Sobel operator form of image2.

Fig 4.3 Prewitt image2
This is the Prewitt operator form of the image2.

Fig 4.4 Laplacian of Gaussian image2
This image is obtained by the experimental analysis of the Laplacian of Gaussian operator of image2.

Fig 4.5 Canny image2

This is the most efficient and optimal method of edge detection. This is obtained by the experimental analysis of Canny edge detection operator of image2.

6. Comparison of Techniques

Techniques	**MSE (image 1)**	**PSNR (image 1)**
Sobel Operator	**14252.8318**	**6.591**
Prewitt's Operator	**16411.8349**	**5.979**
Robert's Operator	**15854.7165**	**6.129**
Canny Operator	**17733.2877**	**5.642**
Log	**17108.4987**	**5.798**

Table.6

For image 1 we have calculated MSE and PSNR for different methods of different edge detection techniques. In the experimental analysis, we came across to analyze that canny operators have been the most efficient and effective method for the detection of edges. Different edge detectors works better under the different cases and conditions, there cannot be any algorithm that make use of multiple edge detectors [15].

Techniques	**MSE (image 2)**	**PSNR (image 2)**
Sobel Operator	**17637.0856**	**5.665**
Prewitt's Operator	**19457.5519**	**5.239**
Robert's Operator	**18554.9019**	**5.446**
Canny Operator	**22284.1644**	**4.638**
Log	**21151.5868**	**4.877**

Table.7

Similarly, we have to calculate the same for image 2. Under this experimental analysis, we find the same that the canny operator for this method has worked out well in all aspects.

We obtained different images for different edge detection techniques. All of them are different in some aspects and the most efficient method is the canny edge detection technique in both cases. All other methods have some blur and noisy labels that affect the efficiency of the image as compared to the canny edge detection techniques.

7.

8. Pros and Cons of Different Edge method

The first derivative gradient-based edge methods such as Sobel, Prewitt, and Roberts are simple in evaluation with fair edge orientation detection but these do not produce good sharp edges and for noisy images, their performance is reduced. The second derivative Laplacian of the gaussian method is good at detecting the correct location of edges along a large pixel area but produces false edges due to high-intensity change at corners and graph with poor edge orientation. Canny edge is an optimal method amongst all those techniques. It provides good response over edge location especially when images are with noise. It uses two thresholds one for strong edges and other for weak edges which are time-consuming. However, it suffers from false zero crossings, which results in missed true edges.

III. Conclusion

In this paper, we dealt with the study of edge detection techniques of Laplacian and gradient-based. The methods and techniques are applied to the whole images. In this, the 2nd order derivative filter produces better results as compared produce the better result as compare to 1st order derivative. In the experiment, it can be shown clearly that some of the methods provides low-quality edge maps as compared to others. Among the methods studied , the Canny method can detect both strong and weak edges, and seems to be more appropriate than the Laplacian of Gaussian. canny edge detection techniques are that it takes a lot of time but efficiently a lot as compared to other techniques.

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