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Critical Review on Edge Detection Techniques in Spatial Domain on Low Illumination Images

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ABSTRACT

Edge detection is continually used operation in image processing. Various standard operations on low illumination images (foggy ,rainy ,sundown) with their advantages and disadvantages are demonstrated in this paper. Comparison of various edge detection under different weather conditions also analyzed here. The review conclude Canny and LoG operators gives better results.

Keywords:-Edge detection, Sobel, Prewitt, Robert, Canny, LoG operators.

I. INTRODUCTION

An edge contains significant local changes of severity at particular point in an image and constituted by connecting groups of pixels on the boundary between two different regions in an image. Edge is a vector variable that contains magnitude and orientation. Edge magnitude: gives the difference between contiguous pixels of the images. Edge orientation: gives the direction of the maximum change across the contiguous edges of images..

II. EDGE DETECTION

Edge detection is basically a most frequent process in image processing that detect location and presence of edges constitute by keen changes in intensity of colour or brightness of an image. It also detect sharp discontinuities in an image. The interruption in images are rapid changes in intensity of pixels values which separate boundaries of objects in an image. The analysis of images by significantly reducing the amount of data in an image simply done by standard edge detection process. Edge detection becomes difficult in case of noisy images as noise contains high frequency components.

III. STEPS IN EDGE DETECTION

Edge detection contain five steps namely-Smoothing Filtering, Enhancement, Detection and Localization. of the steps are as follow.

Smoothing: It contain as much noise as possible, without destroy the sharp edges.

Filtering*:* Images are frequently degraded by random variations in intensity values, called noise. Filtering commonly used to improve the performance of an edge detector with respect to noise .Some common types of noise are salt and pepper noise, impulse noise and Gaussian noise .More filtering to reduce noise results in a loss of edge strength.

Enhancement: Enhancement usually performed by calculating the gradient magnitude of pixels where there is a significant change in local intensity values.

Detection*:* Many points in an image have a nonzero value for the gradient, and all of these points are not edges for a particular application. Frequently, thresholding provides the edge detection criterion in image processing.

Localization: The location of an edge can be calculated with *sub-pixel* resolution if required for applications. Edge thinning and linking are two essential process in localization process.

Edge detection techniques are classified into two groups:

o Gradient

o Laplacian

First-order derivatives are calculating using the gradient in an image. Second-order derivatives are calculating using the Laplacian.

The general syntax for edge detection is:

[g, t] = edge(f, 'method' ,parameters)

Where f is the input image, method is one of edge detection technique and parameters are predefine.

IV.EDGE DETCETION TECHNIQUES

Flow chart of various standard edge detection operators shown below:

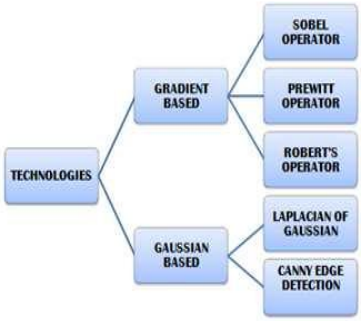

Figure 1: Flow chart of image edge detection

A. Sobel Operator

Sobel operator contains a pair of 3×3 convolution kernels. One kernel is shifted by other kernel by 90°. The kernels can be applied individually to the input image, to produce different measurements of the gradient component in each direction. (known as *Gx* and *Gy*).

In general, an approximate magnitude is computed using:

$$|G| = |Gx| + |Gy|$$

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

Gx

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

Gy

Figure2: Sobel convolution kernel

where Gx and Gy are horizontal and vertical operator .**T**his is much faster to compute.

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

B. Robert's Cross Operator

The Roberts Cross operator gives a simple ,easy to compute, 2-D spatial gradient measurement on an image. Pixel values at each point in the output image represent the approximate absolute magnitude of the spatial gradient of the input image at that point. The operator consists of a pair of 2×2 convolution kernels. One kernel is shifted by other kernel by 90°. This is equivalent the Sobel operator. The kernels can be applied individually to the input image, to produce separate measurements of the gradient component in each direction (known as *Gx* and *Gy*). These

1	0
0	-1

Gx

0	-1
1	0

Gy

Figure3: Roberts cross convolution kernels

measurement can be combined together to find the absolute magnitude of the gradient at each point and the direction of that gradient.

The gradient magnitude is given by:

$|G| = Gx^2 + Gy^2$

An approximate magnitude is computed using:

$|G| = |Gx| + |Gy|$

C. Prewitt's Operator

The Prewitt operator is a discrete operator, which approximate gradient of image intensity**.** The Prewitt operator is inexpensive in terms of computations. Convolution in Prewitt operator is done by shifting the kernel across the frame one pixel at a time. As each pixel and its adjacent are assigned by their corresponding value in the kernel and summarized to produce a new value .

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

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

Gx

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

Gy

Figure 4: Prewitt kernels

(*note*: *Gx* and *Gy* are approximations at (*i*, *j*))

Thus the Gx and Gy of the gradient is calculated by subtracting the upper row to lower row and left column to right column. It is used to compute the gradient of the image intensity at each point and also gives the direction of the maximum possible increase from light to dark and also the rate of change in that direction. The obtained results show how frequently image change at that point.

D. Laplacian of Gaussian (LoG)

The Laplacian is a 2-D uniform measure of the 2nd spatial derivative of an image. The image highlights regions of intensity change and often used for edge detection. The Laplacian is applied to an image with approximating Gaussian smoothing filter and also reduce its sensitivity to noise. The operator takes a single gray level image as input and produces another gray level image as output. The general syntax for the LoG operator

[g, t] = edge(f, 'log', T, sigma)

where sigma is the standard deviation.

The Laplacian can be implemented using the mask shown below:

0	1	0
1	-4	1
0	1	0

1	1	1
1	-8	1
1	1	1

Gx Gy

Figure5: Laplacian of Gaussian kernels

Properties of the Laplacian

Information about edges direction in an image does not provided by LoG operator.

- Due twice differentiation it is more sensitive to noise.
- LoG is an isotropic operator.
- LoG is inexpensive due to one mask only.

E. Canny edge detector

Canny detector is a multi-stage algoritham used to detect wide range of edges in an image Canny detector separate required information from different object and reduce amount of data to be processed . Canny operator is widely used application . It is an unique detection good edge detection results ,unique response and good localization output. It is frequently used in recent image processing techniques due to its adoptive nature with further improve technology.

Importance of Canny

Canny algorithm is considered widely because it contains adjustable parameters which can affect the computation time and effectiveness of the algorithm.

a) The smoothing filter used in the first stage directly affects the results of the detection of edge in small, sharp lines. A larger filter causes more blurring, smearing out the value of an given pixel over a larger area of image.

b) The use of two thresholds with hysteresis allows more flexibility compared to a single-threshold. A threshold value of high miss important information. On the other hand, a threshold set too low will falsely identify irrelevant information (such as noise) .

The edge detection in this technique is optimized with regard to the following criteria .

a) Maximizing the signal-to-noise ratio of the gradient.

b) Edge localization for ensuring the accurate edge.

c) Minimizing multiple responses to a single edge

V. COMPARISON OF EDGE DETECTION TECHNIQUES

Sr. NO.	OPERATOR	ALGORITHAM	ADVANTAGES	DISADVANTAGES
1	ROBERT OPERATOR	The horizontal and vertical edge bring out and chances assembled for resulting edge detection	Easy ,quick to compute	1 accuracy is low 2 cross kernel are low 3 highly susceptible to noise 4 uses single thresholding but streaking
2	SOBEL OPERATOR	Opertor contain 3*3 convolution mask, rotated by 90	Large kernals so less sensitive to noise	1.Slow computation as compared to Robert 2. It focus on pixel closer to the centre on mask
3	Prewitt operator	Same as Sobel	Better performance than Sobel	1 .Sensitive to noise and inaccurate

4	LOG OPERATOR	Lapacian is a 2D isotropic measure with zero crossing	It uses Gaussian to reduce noise and laplacian to detect the sharp edges.	1.Highly probability of detecting false edges. 2.Localization error sever at curved edged. 3 .Laplacian is unable to detect edge direction. 4 unacceptably sensitive to noise.
5	Canny OPERATOR	Advanced optimal edge detection algorithm derived LoG.	1. Reduce probability of detecting false edge and sharper edge. 2 .Less sensitive to noise. 3 .overcame streaking tech uses.	It is time consuming.

VI. EXPERIMENTAL RESULTS

Various edge detection methods like Robert, Canny ,Prewitt, Sobel , LoG operated on images which is shown below.

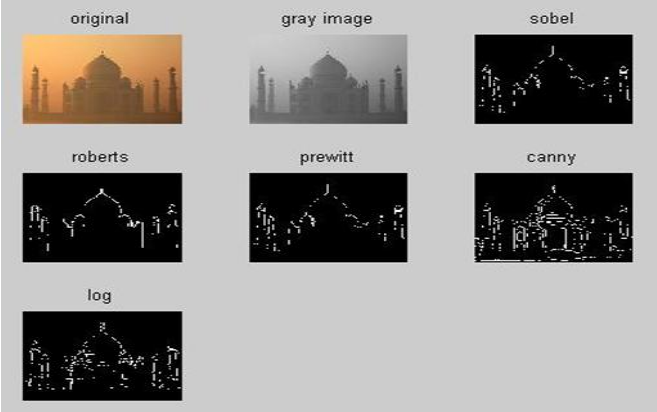

Fig. 6 Foggy image of Tajmahal.

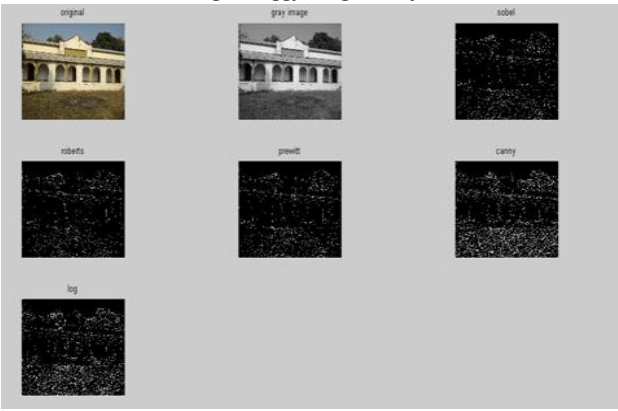

Fig.7 Afternoon image of college building.

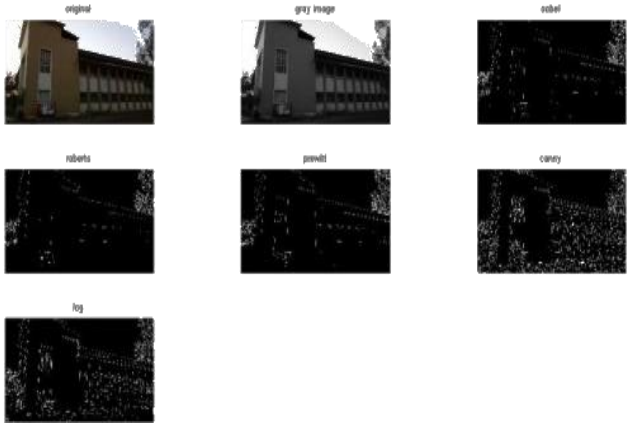

Figure 8. Sunset image of college building

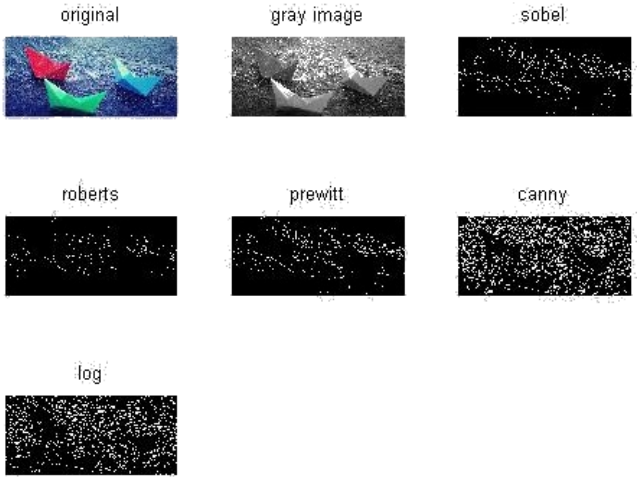

Fig.9 Rainy image

Fig. 10 Various filtering operations on rainy image.

VII. CONCLUSION

The purpose of this paper is to present a review on various edge detection techniques. The study of different edge detection techniques and their experimental results shows that Canny and LoG technique yields best result. The relative performance of various edge detection techniques also performed under different conditions on low illumination images (rainy, sunny and foggy).This low illumination images can be further detected by various standard filtering operations for better results .

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