Edge Detection of Document Image using Shifting and Subtraction Method with Improved Performance

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***Abstract*—Edge detection with improved performance have been proposed to detect the document images comprising alphabet characters. The proposed algorithm approaches the image by shifting and subtracting the latter and for detecting edges in horizontal, vertical and diagonal directions. The image is shifted by one pixel in several directions viz. from left to right, from top to bottom, from top left to right bottom, from left bottom to top right. The shifting also has been done along the reverse directions for each of the above shifting operation. The detected edges of the alphabet characters and image incorporated therein have been found to more obvious and clear compared to those obtained using other edge detectors like Sobel, Canny and LoG filters. The metrics like Pratt's figure of merit (PFOM) and Edge detection error rate (EDER) obtained by proposed algorithm have also been compared to these obtained by using the aforesaid already established edge detectors and also have been found to yield better metrics. The present method of edge detection is expected to find versatile applications in archive documentation, libraries and criminal history recordings.**

Keywords—image shifting; PFOM; EDER; edge detector.

I. INTRODUCTION

Edge detection is nothing but the detection of connected pixels (straight line or curve) where the image (or pixels within the image) intensity level changes drastically. The drastic change in intensity levels can be detected using spatial domain filtering [1] such as sharpening spatial domain filtering. The filtering result depends on the weights of convolution kernel or mask. Several methods [2], [3], [4] have been developed for detecting the edges of an image using several types of mask. The main idea behind the all algorithms is to subtract one intensity from next i.e. gradient calculation with neighboring pixels. But all the cases getting result is vague if the intensity levels of the image changes periodically within a small spatial interval.

The improved method of segmentation or the proposed method is to finding the edges in all the direction using shifting and subtraction method. In the present method the gradient is calculated between two subsequent pixels, so the detected edges are very sharp and precise and is suitable for detecting edges of the image where the intensity levels of the image changes periodically within a small spatial interval. In the next section (section II and III) the proposed method is described explicitly.

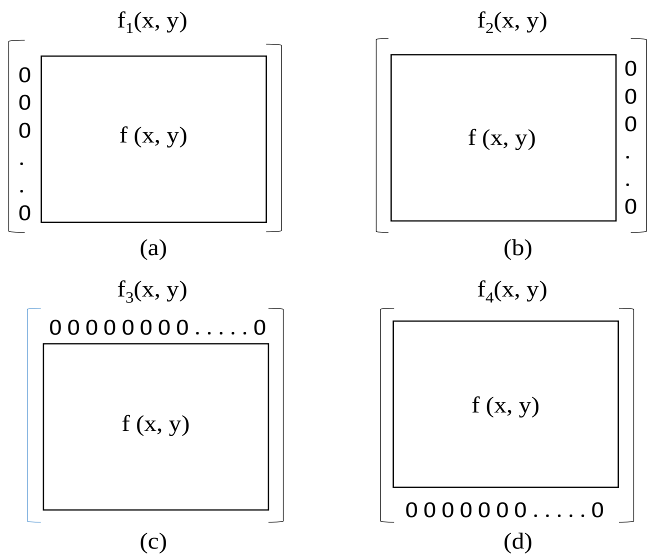
II. APPROACH

An image can be written as follows,

$$f(x, y) = \begin{bmatrix} f(1,1) & f(1,2) & f(1,3) & . & . & f(1,n) \\ f(2,1) & f(2,2) & f(2,3) & . & . & f(2,n) \\ f(3,1) & f(3,2) & f(3,3) & . & . & f(3,n) \\ f(4,1) & f(4,2) & f(4,3) & . & . & f(4,n) \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ f(m,1) & f(m,2) & f(m,3) & . & . & f(m,n) \end{bmatrix}$$

where m denotes the total number of rows and n denotes the total number of columns of the image.

Now zeroes are padded separately in the left, right, top, bottom, left-top, right-top, left-bottom and right-bottom sides of the image f(x, y) is as shown in Fig. 1. The main idea behind the padding is to shifting of the image pixel elements in different directions. For example if a zero is padded in the left side as a first element in each row of the image then the image pixels are shifted towards right by one pixel element.



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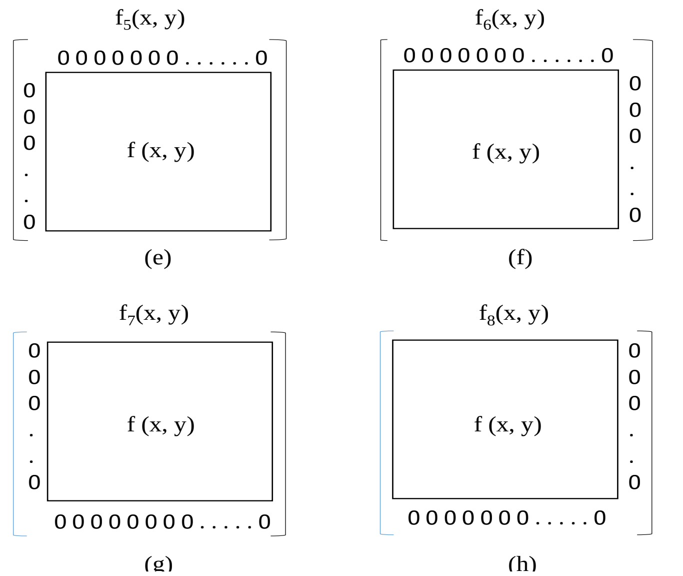


Fig. 1. Zero padding for image shifting. (a) Shifting towards right, (b) shifting towards left, (c) shifting towards downward, (d) shifting towards upward, (e) shifting towards top left to right bottom, (f) shifting towards right bottom to top left, (g) shifting towards left bottom to top right, (h) shifting towards top right to left bottom.

From the above Fig. 1 the shifted image has been defined symbolically and it can be noted that after padding size of the image has been increased. But the resultant image should in equal size of the original image. So after operation we have to discard the same number of elements, which have been padded with the original image. The selection of elements to be discarded is an important factor in present method of image segmentation.

III. PROPOSED METHOD

Proposed method of edge detection is based on image shifting and subtraction. The subtraction is taken place between two opposite directionally shifted images. After subtraction the same number of elements are discarded which have been padded with the original image. The present method of edge detection is described as below,

i) Subtract $f_2(x, y)$ from $f_1(x, y)$, mathematically written as,

$$f_{12}(x, y) = f_1(x, y) - f_2(x, y) \tag{1}$$

from $f_{12}(x, y)$ last column is discarded.

ii) Subtract $f_1(x, y)$ from $f_2(x, y)$, mathematically written as,

$$f_{21}(x, y) = f_2(x, y) - f_1(x, y) \tag{2}$$

from $f_{21}(x, y)$ first column is discarded.

iii) Subtract $f_4(x, y)$ from $f_3(x, y)$, mathematically written as,

$$f_{34}(x, y) = f_3(x, y) - f_4(x, y) \tag{3}$$

from $f_{34}(x, y)$ last row is discarded.

iv) Subtract $f_3(x, y)$ from $f_4(x, y)$, mathematically written as,

$$f_{43}(x, y) = f_4(x, y) - f_3(x, y) \tag{4}$$

from $f_{43}(x, y)$ first row is discarded.

v) Subtract $f_6(x, y)$ from $f_5(x, y)$, mathematically written as,

$$f_{56}(x, y) = f_5(x, y) - f_6(x, y) \tag{5}$$

from $f_{56}(x, y)$ last row and last column is discarded.

vi) Subtract $f_5(x, y)$ from $f_6(x, y)$, mathematically written as,

$$f_{65}(x, y) = f_6(x, y) - f_5(x, y) \tag{6}$$

from $f_{65}(x, y)$ first row and first column is discarded.

vii) Subtract $f_8(x, y)$ from $f_7(x, y)$, mathematically written as,

$$f_{78}(x, y) = f_7(x, y) - f_8(x, y) \tag{7}$$

from $f_{78}(x, y)$ first row and last column is discarded.

viii) Subtract $f_7(x, y)$ from $f_8(x, y)$, mathematically written as,

$$f_{87}(x, y) = f_8(x, y) - f_7(x, y) \tag{8}$$

from $f_{87}(x, y)$ last row and first column is discarded.

After subtracting and ignoring eight components have been found. Each component bear edge information in a particular direction. For example $f_{12}(x, y)$ and $f_{21}(x, y)$ bear the information about the vertical edges. Because to forming these two matrices horizontal shifting have taken place in both right and left direction. Edge information for other matrices can be defined similarly. Finally the eight components are added together for getting the resultant edge information.

IV. RESULTS AND PERFORMANCE MEASUREMENT

The edge detection of an image using proposed method is shown in Fig.2 and 5 with a certain part of a scanned document image from an Indian daily, Tripura times of size 536x376 and an image of a car including number plate of size 320x240.

UPA vulnerable after DMK pullout, Pawar

THANE, Apr. 13, (PTI): Key UPA ally NCP chief Sharad Pawaron Saturday said the Centre's ruling coalition had become "vulnerable" after DMK's pullout and that elections were round the corner.

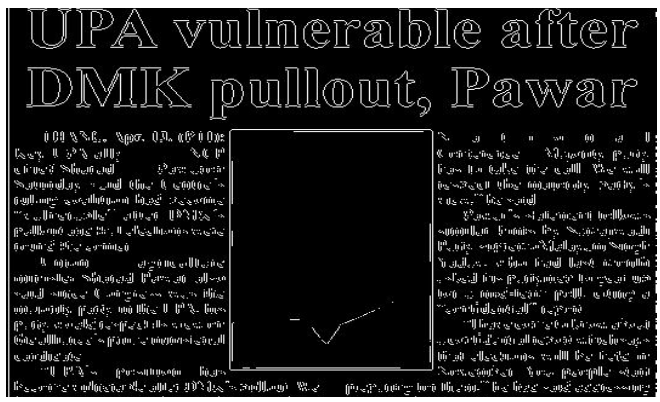
Union agriculture minister Sharad Pawar also said since Congress was the majority party in the UPA, his party would respect its view on the alliance's prime ministerial candidate.

"UPA's position has become vulnerable after DMK's pullout. We ... National Conference.....Majority party has to take the call. We will respect the majority party's view," he said.

Pawar's statement follows similar hints by Samajwadi Party supremoMulayam Singh Yadav, who had last month asked his partymen to gear up for a mid-term poll, citing a "confidential" report.

"I have come to know about a confidential report which says that elections will be held in November. You people start preparing for them," he had said addressing

(a)



(b)

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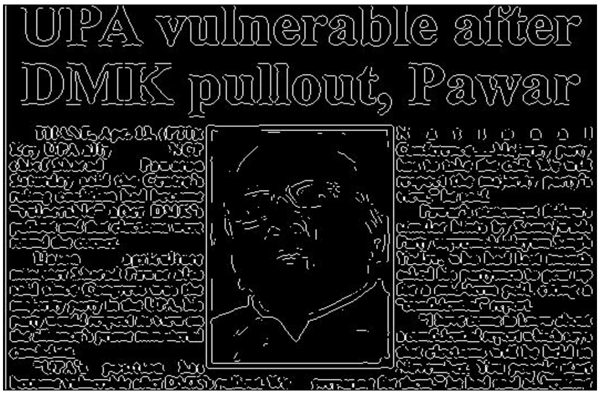

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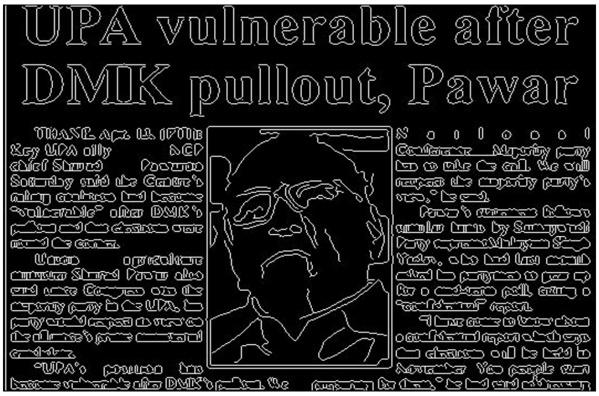

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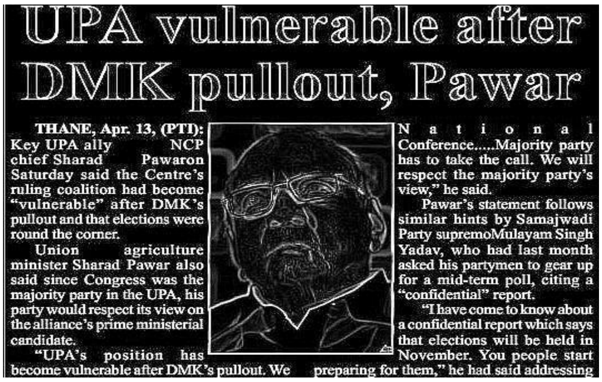

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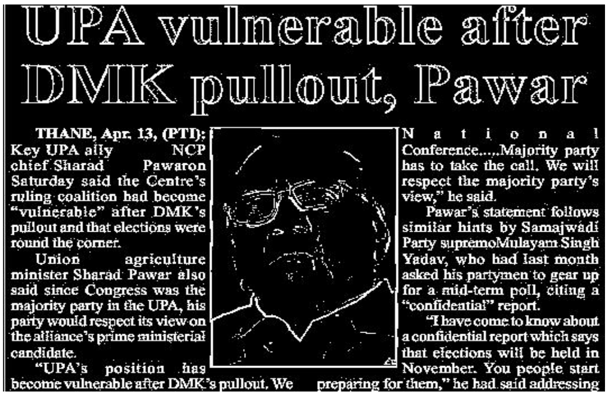

(f)

Fig. 2. Edge detection of the document image using several method. (a) Original image, (b) using Sobel, (c) using LoG, (d) using Canny, (e) using Proposed Method, (f) Binary image of (g) keeping threshold value to .4.

The performance of the present method is measured by the metrics, A) Pratt's figure of merit (PFOM) [8] and B) edge detection error rate (EDER) [9].

A. Pratt's figure of merit

Mathematically Pratt's figure of merit (PFOM) is given as,

$$R = \frac{1}{I_N} \sum_{i=1}^{I_A} \frac{1}{1 + ad^2} \tag{9}$$

where $I_N = \max\{I_I, I_A\}$, I_I stands for the number of ideal edge map points and I_A represents the number of actual detected edge map points, d is the distance of separation of an actual edge point normal to a line of ideal edge points and a is the scaling constant. In the present study a=1/9.

From equation (9), it can be noted that R is inversely proportional to d. Thus for a smeared edge, the distance d between the ideal and actual edge map increases and consequently, the value of R is reduced. As a result, the edge detector which results in localized edge points has a lower value of d and hence a high value of R. Therefore, the ideal edge map points have key importance in evaluating the performance of edge detectors using PFOM. To un-bias the performance quantification values of R, for respective detectors have been extracted from the noise-free image.

B. Edge Detection Error Rate

Mathematically edge detection error rate is given as,

$$P_e = n_1/n_0 \tag{10}$$

where n_0 is the number of edge pixels declared and n_1 be number of missed or new edge pixels after adding noise. n_0 is held fixed noiseless as well as the noisy image. From the above equation (10), it is clear that for better performance P_e should be as small as possible.

We added Gaussian noise to the image for analyzing the performance metrics. PFOM and EDER is obtained for the document image for different values of PSNR and is compared with the other method of edge detectors. Following Table I shows the tabular representation of obtained values of PFOM and EDER for the document image and their comparison is pictorially shown in Fig. 3 and 4.

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TABLE I
Performance Metrics (Pratt's figure of merit and Edge detection error rate) of various edge detectors of the document image.

PSNR (dB)	Metrics	Edge Detector Type			
		Sobel	LoG	Canny	Proposed Method
44	PFOM	0.9973	0.9933	0.9879	0.9986
	EDER	0.0196	0.0151	0.0144	0.0138
36	PFOM	0.9854	0.9842	0.9760	0.9868
	EDER	0.0458	0.0364	0.0330	0.0331
30	PFOM	0.9725	0.9523	0.9470	0.9777
	EDER	0.0882	0.0723	0.0647	0.0625
26	PFOM	0.9299	0.9075	0.9001	0.9323
	EDER	0.1387	0.1149	0.1089	0.1043
24	PFOM	0.9007	0.8836	0.8705	0.8895
	EDER	0.1710	0.1476	0.1287	0.1343

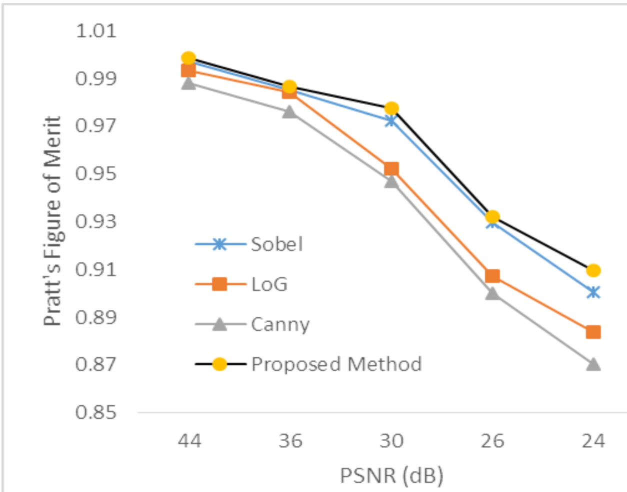


Fig. 3. Pratt's figure of merit vs. PSNR of various types of edge detectors for the document image and their graph is shown with different color line.

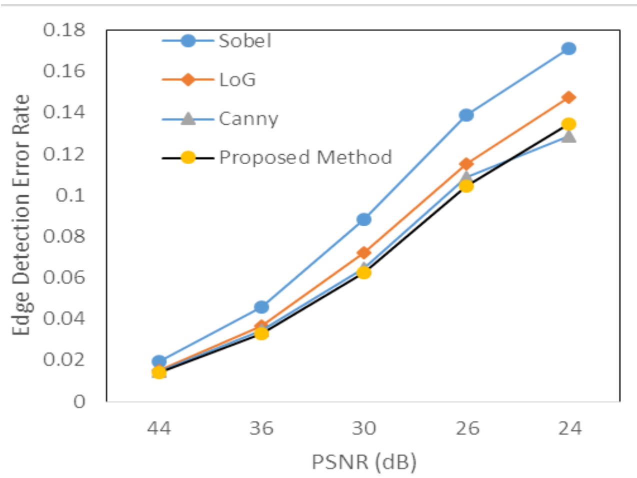
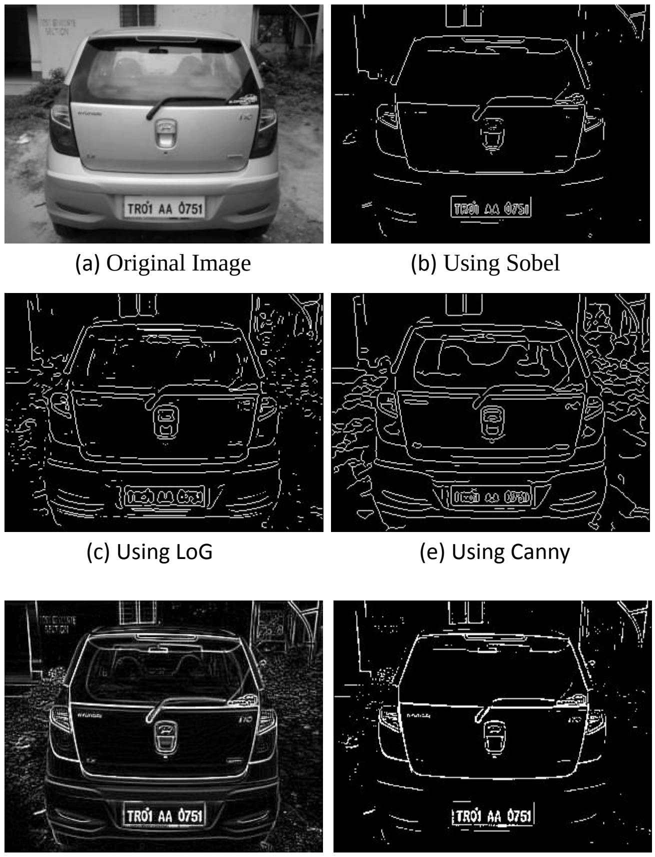


Fig. 4. Edge detection error rate of various types of edge detectors for the document image and their graph is shown with different color line.

Following Fig. 5 shows the edge detection of a car including number plate of size 320x240.



(a) Original Image (b) Using Sobel

(c) Using LoG (e) Using Canny

(e) Using Proposed Method (f) Binary image keeping T=.4

Fig. 5. Edge detection of an image of an car including number plate. a) Original image, (b) using Sobel, (c) using LoG, (d) using Canny, (e) using Proposed Method, (f) Binary image of (g) keeping threshold value to .4.

Following Table II shows the tabular representation of obtained values of PFOM and EDER for the car image and their comparison is pictorially shown in Fig. 6 and 7.

TABLE II
Performance Metrics (Pratt's figure of merit and Edge detection error rate) of various edge detectors of the car image.

PSNR (dB)	Metrics	Edge Detector Type			
		Sobel	LoG	Canny	Proposed Method
44	PFOM	0.9966	0.9923	0.9868	0.9975
	EDER	0.0296	0.0251	0.0244	0.0338
36	PFOM	0.8824	0.8742	0.8760	0.8868
	EDER	0.0458	0.0464	0.0430	0.0531
30	PFOM	0.8425	0.8323	0.8270	0.8577
	EDER	0.0882	0.0723	0.0647	0.0725

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PSNR (dB)	Metrics	Edge Detector Type			
		Sobel	LoG	Canny	Proposed Method
26	PFOM	0.8299	0.8075	0.8001	0.8123
	EDER	0.1687	0.1449	0.1289	0.0943
24	PFOM	0.7907	0.7836	0.8005	0.7895
	EDER	0.1910	0.1776	0.1387	0.1243

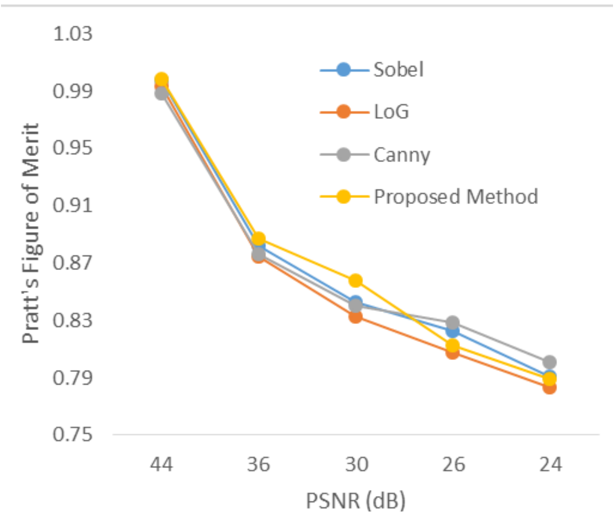

Fig. 6. Pratt's figure of merit vs. PSNR of various types of edge detectors for the car image and their graph is shown with different color line.

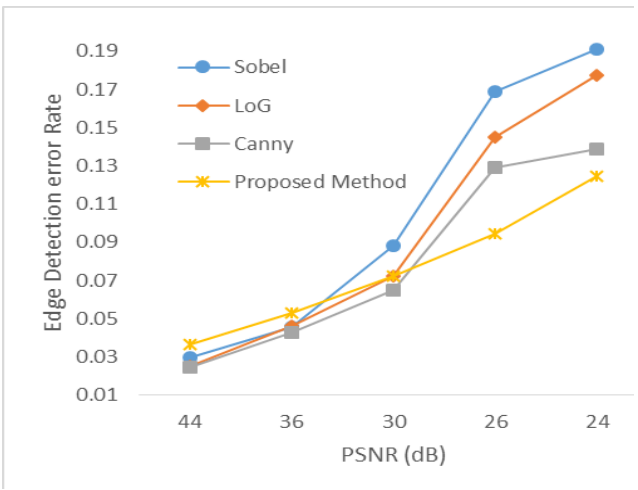

Fig. 7. Edge detection error rate vs. PSNR of various types of edge detectors for the car image and their graph is shown with different color line.

The proposed method have been applied on the real life image of certain part of a local daily in India and a backside of a car including number plate. In both of the images improved evaluation measures have been achieved compared with those based on previous algorithms proposed by earlier researchers, the outcome of the present study is expected to inputs in better ways for higher level image processing than image segmentation.

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References

[1] R. Gonzalez and R. Woods, Digital Image Processing. Prentice Hall, 2008.

[2] I. Sobel, "Camera models and machine perception," Stanford University, Stanford AI MEMO 121, 1970.

[3] S. Liqin, S. Dinggang, and Q. Feihu, "Edge Detection on Real Time Using LOG Filter," IEEE Symposium on Speech, Image Processing and Neural Networks, pp. 37-40, apr. 1994.

[4] J. Canny, "A computational approach to edge detection," IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 8, no. 6, pp. 679 -698, nov. 1986.

[5] E. Nezhadarya, and R. K. Ward, "A New Scheme for Robust Gradient Vector Estimation in Color Images," IEEE Transactions on Image Processing, vol. 20, pp. 2211 – 2220, 2011.

[6] X. Wang, "Laplacian Operator-Based Edge Detectors," IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 29, pp. 886 – 890, 2007.

[7] S. Pande, V. S. Bhadouria, and D. Ghoshal, "A study on edge marking scheme of various standard edge detectors," International Journal of Computer Applications, vol. 44, pp. 33- 37, 2012.

[8] W. Pratt, Digital Image Processing. 1ohn Wiley & Sons, 1991.

[9] A. K. Jain, Fundamentals of Digital Image Processing. Prentice Hall of India, 2001.

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