International Journal of Modern Electronics and Communication Engineering (IJMECE) ISSN: 2321-2152
Volume No.-6, Issue No.-6, November, 2018

A Comparative Analysis of Edge Detection Algorithm and Performance Metric Using Precision, Recall and F- Score

Naveen Singh Dagar
Research Scholar,
Deenbandhu Chhotu Ram University of Science & Technology, Murthal, Haryana, India-131039
E-mail: naveendagar87@gmail.com

Pawan Kumar Dahiya
Assistant Professor,
Deenbandhu Chhotu Ram University of Science & Technology, Murthal, Haryana, India-131039
E-mail: pawan.dahiya@gmail.com

Abstract: Edge detection is a standout amongst the most generally utilized activities in picture analysis. Edge detection is the first step in numerous PC vision applications. Edge detection significantly decreases the measure of information and filters out undesirable or insignificant information and gives the significant information in a picture. This information is utilized as a part of picture preparing to distinguish objects. The purpose behind this is edges form the layout of a question. An edge is the limit between a protest and the foundation, and shows the limit between covering objects. This implies if the edges in a picture can be identified precisely, the majority of the articles can be found and fundamental properties, for example, territory, edge, and shape can be estimated. There are a few issues like false edge detection, issues because of clamour, missing of low differentiation limits and so forth. This paper introduces a correlation between different edge indicators to identify which edge locator performs better outcomes. In this paper, we have thought about a few systems for edge detection on BSDS500 datasets of pictures. The ground truth pictures are taken as reference edge pictures and all the edge pictures acquired by different edge detection systems are contrasted with reference edge picture with ascertain the performance metrics. We think about Precision, Recall and F-Score performance metrics utilized as a part of picture preparing connected to pictures in this correlation.

Keywords: Image Processing, Edge Detection, Precision, Recall, F-Score, BSD500, TP, FP, FN.

I. INTRODUCTION

Edge detection is an imperative zone in the field of Computer Vision. It has turned into the foundation of example acknowledgment and feature extraction in a low-level picture preparing. The primary objective of edge detection is to find and identify sharp discontinuities from a picture. These discontinuities are because of unexpected changes in pixel force which describes limits of items in a scene. Edges give limits between different districts in the picture. These question limits are the first step in a considerable lot of PC vision algorithms like edge based face acknowledgment, edge based impediment detection, edge based target acknowledgment, picture pressure and so forth. So the edge identifiers are required for removing the edges. There are numerous edge detection administrators accessible [1].These administrators identifying vertical, flat, corner and step edges. The nature of edges identified by these administrators is very subject to commotion, lighting conditions, objects of same powers and the thickness of edges in the scene. These issues can be fathomed by modifying different parameters in the edge indicator and changing the estimations of edge for what an edge is considered. No strategy has been proposed for self-adjusting these qualities [2]. These administrators are exceptionally touchy to clamor and edges that contain high frequency substance. So expulsion of commotion is required that may bring about obscured and twisted edges. An extensive variety of administrators are accessible that can separate the edges from boisterous picture [3] [4]. Yet, these edges are less exact. That is because of the nearness of commotion they extricate false edges. They don't find the limits of protest having little change in forces esteems. That outcome in poor limitation of edges So, the administrator is required to identify such a progressive change in powers. So, there are issues of false edge detection, issue because of commotion, missing of low difference limits, high computational time and so forth. Therefore, objective is to do the examination between different edge finders and break down which edge identifier performs better. The edge detection essentially assesses a picture and produces a pixel at the limit of two different unexpected forces. The yield picture is the blend of every single such pixel made amid the detection [5]. The technique utilized to distinguish unexpected changes or intermittence of pixel force assumes an essential part in edge detection algorithm.

The paper is sorted out as follows: Section 1 gives an Introduction to edge detection. Area 2 introduces an outline of related work. Segment 3 elucidates the hypothetical foundation of different edge identifiers and performance metrics. The trial comes about are given in Section 4. Segment 5 makes the finishing up comments.

II. RELATED WORK

Different sorts of administrators are accessible for edge detection. Yet, these administrators are classified into two classifications. In First request subsidiary [2] the information picture is convolved by an adjusted veil to produce an inclination picture in which edges are distinguished by thresholding. Most traditional administrators like sobel, prewitt, robert [5] are the first request subordinate administrators. These administrators are additionally said as angle administrators. These inclination administrators identify edges by searching for greatest and least force esteems. These administrators inspect the conveyance of power esteems in the area of a given pixel and decide whether the pixel is to be classified as an edge. These administrators have more computational time and can't be utilized as a part of constant application. In second request subsidiary [2], these depend on the extraction of zero intersection focuses which shows the nearness of maxima in the picture. In this, picture is first smoothed by a versatile filters [4].Since the second request subordinate is exceptionally sensible to commotion, and the filtering function is critical. These administrators are gotten from the Laplacian of a Gaussian (LOG), and proposed by Marr and Hildreth [3], in this, the picture is smoothed by a Gaussian filter. For this administrator we need to fix a few parameters, for example, the fluctuation of the Gaussian filter and limits. A few strategies are accessible for their programmed calculation [7], however much of the time their qualities must be fixed by the client. A significant issue of LoG is that the limitation of edges with an asymmetric profile by zero-intersection focuses presents an inclination which increments with the smoothing effect of filtering [8].An fascinating answer for this issue was proposed by Canny [6], which says in an ideal administrator for step edge detection incorporates three criteria: great detection, great confinement, and just a single reaction to a solitary edge. After that different administrators have been proposed [12][13][14][15].These administrators gives great efficiency against boisterous pictures, yet they offers some utmost about limitation when distinguishing edge composes other than those for which they are ideal [16].In last we infer that none of the genuine edge indicators in view of the first or the second subordinate of a picture meets our criteria in light of the fact that the obscuring effect of pre-preparing, and the administrator linearity makes a confinement accurately recognize any edge form.

III. THEORETICAL BACKGROUND

3.1 Classical Method

Edge Detection based on computing the gradient for the pixels and detecting the local maxima to localize the step edges.

$$\left|\widehat{\nabla_g}(c,r)\right| = \left|\sum_\alpha g_\alpha(c,r)\right| \qquad (1)$$

It is a basic method for the detection of the edges and their orientation [5]. The technique being simple is based radically on the discrete differential operators. The Sobel edge detector is a simple and an effective operator but is disturbed by noise easily and is not useful in detecting the outermost edges clearly. The Prewitt operator does not provide the smoothing provided by the Sobel operator. The major drawback seen in these methods is that it is sensitive to noise and is not accurate [4].

3.1.1 Roberts Edge Detector

The Robert Edge Detector is based on the 2D spatial gradient measurement of the image. The Edge Detection is performed by the high spatial frequencies [5]. The magnitude of the spatial gradient of the input image for each different pixel is provided as the output for each pixel, a gray scale image. The convolution kernel used is as shown in the Figure1.Robert proposed
The equation

$$y_{i,j} = \sqrt{x_{i,j}} \qquad (2)$$

$$z_{i,j} = \sqrt{\left(y_{i,j} - y_{i+1,j+1}\right)^2 + \left(y_{i+1,j} - y_{i,j+1}\right)^2} \qquad (3)$$

x- Initial intensity of the image

z- Derivative computed. **i, j**- location in the image.

1	0
0	-1

0	1
-1	0

Fig.1. Convolution kernels for Robert Edge detection

3.1.2 Sobel Edge Detection

The method is similar to the Roberts operator. It finds the approximate absolute gradient magnitude at each point. Here the operator consists of 3x3 convolution kernels. One kernel is the other rotated by 90 degree. Finally, the gradient magnitude is thresholded [9].

$$|G| = \sqrt{G_x^2 + G_y^2} \qquad (4)$$

$$q = \arctan\left(\frac{G_x}{G_y}\right) \qquad (5)$$

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

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

Fig.2. Convolution kernels for Sobel Edge *detection*

3.1.3Prewitt Edge Detection

The Prewitt edge detection system was given to conquer the issue faced in Sobel Edge Detection because of the absence of the smoothing modules. The operator adds a vector value keeping in mind the end goal to give smoothing [14]. This operator or algorithm gives a way to estimate both the magnitude and the orientation of an edge [23].

$$|G| = \sqrt{G_x^2 + G_y^2} \qquad (6)$$

$$\theta = atan2(G_x, G_y) \qquad (7)$$

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

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

Fig.3. Convolution kernels for Prewitt Edge detection

It It includes both the horizontal and the vertical edge positions. It is restricted to 8 potential outcomes of orientation. The convolution mask with the largest module is currently chosen [16].

3.2The Optimal Edge Detection Strategies (Gaussian Method)

The strategy given by Marr-Hilderth test the idea, that an edge compares to a change in the image orientation, in this way informing that it is much serious to find the zero intersection position than the maxima. Because of the utilization of the Laplacian filter, the corners and bends are not distinguished accurately. To beat these disadvantages the enhanced strategies, the Canny and the ISEF strategies for the optimal Edge Detection system is utilized [20]. The Canny operator analyzed the item with the Gaussian first request derivative to identify the boundary. The likelihood of pixels at the boundary being commotion was identified. This leads to the ISEF algorithm (Shen and Castan's filter) giving better signal to commotion ratio [23].

3.2.1 Laplacian of Gaussian (LoG) Edge Detection

The major change is seen over in the commotion diminishment. A 2D Gaussian function is utilized to convolve the image

$$L(x,y) = \nabla^2 f(x,y) = \frac{\partial^2 f(x,y)}{\partial x^2} + \frac{\partial^2 f(x,y)}{\partial y^2} \quad (8)$$

$$LoG(x,y) = -\frac{1}{\pi\sigma^4}\left[1 - \frac{x^2+y^2}{2\sigma^2}\right] e^{-\frac{x^2+y^2}{2\sigma^2}} \quad (9)$$

The Laplacian is then computed and the pixels with zero crossing are considered as edges [8].

Image pyramid is a method of applying repeated smoothing. The pyramid is based on two filters the low pass filter and the high pass filter.

3.2.2Canny Edge Detection

The Canny edge indicator is broadly thought to be the standard edge detection algorithm in the business. It was first created by John Canny for his Masters proposal at MIT in 1983 [6], and still outperforms many of the more up to date algorithms that have been produced. Canny saw the edge detection issue as a signal handling optimization issue, so he built up a target function to be enhanced [6]. The answer for this issue was a rather complex exponential function, yet Canny found several ways to approximate and advance the edge-searching issue. The means in the Canny edge indicator are as follows:

1. Smooth the image with a two dimensional Gaussian. As a rule the computation of a two dimensional Gaussian is expensive, so it is approximated by two one dimensional Gaussians, one in the x heading and the other in the y bearing.

2. Take the gradient of the image. This shows changes in power, which indicates the nearness of edges. This actually gives two outcomes, the gradient in the x course and the gradient in the y bearing.

1. Non-maximal concealment. Edges will happen at focuses the where the gradient is at a maximum. Therefore, all focuses not at a maximum ought to be stifled. With a specific end goal to do this, the magnitude and heading of the gradient is registered

at each pixel. At that point for each pixel check if the magnitude of the gradient is greater at one pixel's distance away in either the positive or the negative course perpendicular to the gradient. If the pixel isn't greater than both, stifle it.

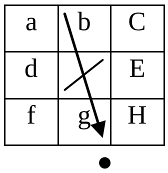


Fig.4 From Central gradient value interpolate gradient value at ● from gradient value at e, g and h, Repeat in opposite direction. Suppress if non maximum

2. Edge Thresholding. The strategy for thresholding utilized by the Canny Edge Detector is referred to as "hysteresis". It makes utilization of both a high limit and a low edge. If a pixel has a value above the high limit, it is set as an edge pixel. If a pixel has a value above the low limit and is the neighbor of an edge pixel, it is set as an edge pixel as well. If a pixel has a value above the low edge however isn't the neighbor of an edge pixel, it isn't set as an edge pixel [6]. If a pixel has a value underneath the low edge, it is never set as an edge pixel.

3.3 Detection Performance Measures

In detection problems, systems are designed to decide whether a given event or feature is present or absent in a given space. Given a ground-truth annotation, the ideal system behaviour is to detect all possible entities without giving any false alarms. Quantifying a system performance is normally done by combining True/False Positives/Negatives to measure the Precision and Recall [20]. Precision measures the rate of true positives among all the detections, while Recall measures the percentage of detected ground truth annotations.

They are defined by:

$$Precision = \frac{TP}{TP+FP} \qquad (10)$$

$$Recall = \frac{TP}{TP+FN} \qquad (11)$$

TP- TRUE POSITIVE, TN- TRUE NEGATIVE FP-FALSE POSITIVE, FN- FALSE NEGATIVE

The ideal system corresponds to precision and recall equal to one. In practice, a compromise between these two quantities exists: a system with a high recall is likely to have false positives, and a system with high precision is likely to miss some true annotations. Often, the two quantities are summarized into a single number, F, defined as the harmonic mean of precision and recall:

$$F\ Score = \frac{2*Precision\ *Recall}{Precision\ +Recall} \qquad (12)$$

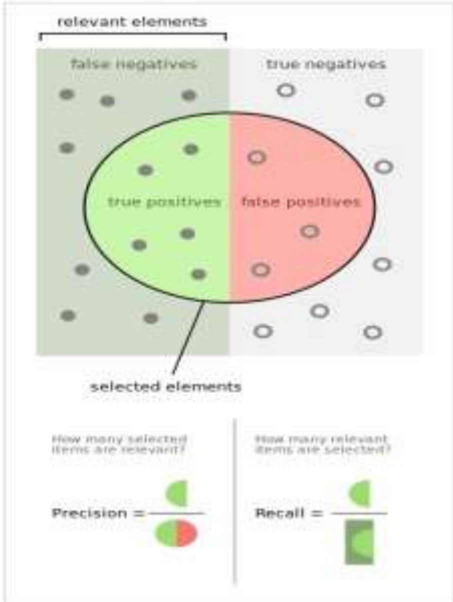


Fig.5 Precision & Recall

IV. EXPERIMENTAL RESULTS

In the past two decades several algorithms have been developed to extract edges within digital images but their functionalities and performances are not the same. In spite of all the efforts, none of the proposed operators are fully satisfactory in real world. The availability of well-defined quality criteria is important; these criteria should consider Precision, Resolution and Accuracy [20, 21]. Precision, Recall and F-Score are our chosen criteria to compare different algorithms. Five edge detectors in the context of the above mentioned classification, which are more commonly in use, are selected and then tested. We perform some experiment for making comparison between different edge detectors on the test images taken from the BSDS500 datasets [10].

We have taken three images from the BSDS500 datasets. Images are numbered as 8049, 22013 & 23025 respectively and the images are segmented to obtain the ground truth images for reference edge images. Different edge operators are applied to the images to obtain the edge image.

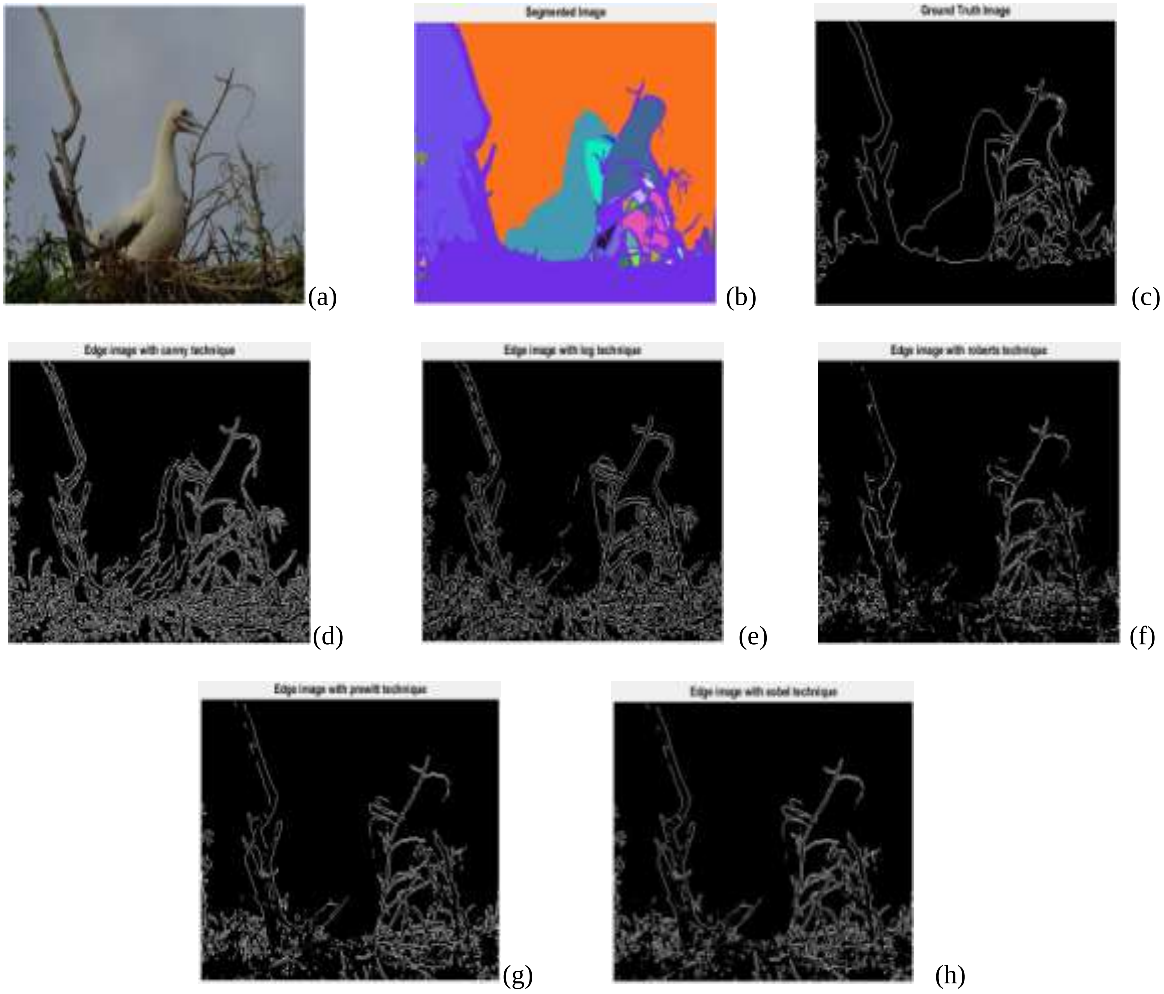
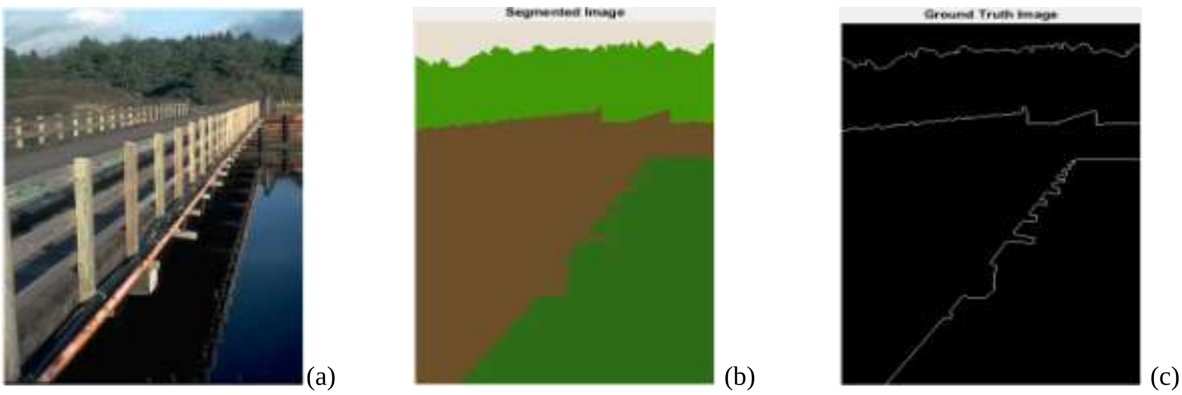


Fig.6 (a) Image 8049 (b) Segmented Image (c) Ground Truth Image (d) Canny Edge Image (e) LOG Edge Image (f) Roberts edge image (g) Prewitt Edge Image (h) Sobel Edge Image

Table 1 for Image No.8049

Operators	Precision	Recall	F- Score
Canny	**0.3674**	**0.3898**	**0.3782**
LOG	0.2054	0.2181	0.2116
Robert	0.2163	0.2287	0.2224
Prewitt	0.1868	0.2031	0.1946
Sobel	0.1765	0.2055	0.1899



(d)

(e)

(f)

(g)

(h)

Fig.7 (a) Image 22013 (b) Segmented Image (c) Ground truth Image (d) Canny Edge Image (e) LOG Edge Image (f) Robert Edge Image (g) Prewitt Edge Image (h) Sobel Edge Image

Table 2 for image no. 22013

Operators	Precision	Recall	F- Score
Canny	**0.4368**	**0.4510**	**0.4438**
LOG	0.2874	0.2905	0.2889
Robert	0.3024	0.3272	0.3143
Prewitt	0.1765	0.1919	0.1838
Sobel	0.1678	0.1934	0.1796


(a)

(b)

(c)

(d)

(e)

(f)

(g)

(h)

Fig.8 (a) Image 23025 (b) Segmented Image (c) Ground Truth Image (d) Canny Edge Image (e) LOG Edge Image (f) Robert Edge Image (g) Prewitt Edge Image (h) Sobel Edge Image

Table 3 for Image no. 23025

Operators	Precision	Recall	F- Score
Canny	**0.2987**	**0.3211**	**0.3095**
LOG	0.1564	0.1472	0.1517
Robert	0.1879	0.2090	0.1978
Prewitt	0.1487	0.1522	0.1504
Sobel	0.1652	0.1537	0.1592

V. CONCLUSION

Since edge detection is the initial advance in question acknowledgment, it is important to know the differences between edge detection systems. This paper displays a comparison between various edge detectors to identify which edge identifier performs better outcomes. In this paper, we have compared several systems for edge detection on BSDS500 datasets of images. The ground truth images are taken as reference edge images and all the edge images obtained by various edge detection strategies are compared with reference edge image to calculate the performance metrics. We think about Precision, Recall and F-Score performance metrics utilized as a part of image handling applied to images in this comparison. The software is produced using MATLAB R2015a. Canny's edge detection algorithm is computationally more costly compared to Sobel, Prewitt, LOG and Robert's operator. Be that as it may, the Canny's edge detection algorithm gives the most astounding Precision, Recall and F-Score value as compared to the next edge locators under almost all scenarios. Evaluation of the images demonstrated that under all conditions, canny display better performance.

REFERENCES

[1]. E. Argyle. “Techniques for edge detection,” Proc. IEEE, vol. 59, pp. 285- 286, 1971.
[2]. Larry S. Davis, A Survey of Edge detection Techniques, Computer Graphics and Image Processing. (1975) 4, (248-270).
[3]. D. Marr and E. Hildreth, Theory of edge detection, Proc. R. Soc. London B207, 187-217 (1980).

[4]. T. Peli and D. Malah, A study of edge detection algorithms, Computer Graphics and Image Processing. 20, 1-21 (1982).

[5]. V. Torte and T. A. Poggio, On edge detection, IEEE Trans. Pattern Anal. Mach. Intell. PAMI-8, 147-163 (1986).

[6]. J. Canny, A computational approach to edge detection, IEEE Trans. Pattern Anal. Mach. lntell. PAMI-8, 679-698 (1986).

[7]. Subhasis Chaudhuri, Shankar Chatterjee, Norman Katz. Mark Nelson, And Michael Goldbaum, Detection of Blood Vessels in Retinal Images Using Two-Dimensional Matched Filters, IEEE Transactions On Medical Imaging, VOL. 8, NO. 3, SEPTEMBER 1989.

[8]. A. Rangarajan, R. Chellappa, And Y. T. Zhou, A Model-Based Approach for Filtering and Edge Detection in Noisy Images, IEEE Transactions On Circuits And Systems, VOL. 37, NO. 1, JANUARY 1990.

[9]. Nikhil R. Pal and Sankar R. Pal, A Review On Image Segmentation Techniques, Pattern Recognition, VOL. 20, NO.9, pp. 1277- 1294, 1993.

[10]. Suchendra M. Bhandarkar, Yiqing Zhang And Walter D. Potter, An Edge Detection Technique Using Genetic Algorithm-Based Optimization, Pattern Recognition, Vol. 27, No. 9, pp. 1159 1180, 1994 Elsevier Science Ltd Copyright © 1994 Pattern Recognition Society.

[11]. J. Scharcanski and A. N. Venetsanopoulos, Edge Detection of Color Images Using Directional Operators, IEEE Transactions On Circuits And Systems For Video Technology, Vol. 7, No. 2, April 1997.

[12]. Djemel Ziou and Salvatore Tabbone, Edge Detection Techniques- An Overview, Computer Graphics and Image Processing, pp.1 – 41, 1998.

[13]. Carlo Bruni, Alberto De Santis, Daniela Iacoviello and Giorgio Koch, Modeling for Edge Detection Problems in Blurred Noisy Images, IEEE Transactions On Image Processing, VOL. 10, NO. 10, OCTOBER 2001.

[14]. Mohsen Sharifi, Mahmoud Fathy, Maryam Tayefeh Mahmoudi, Classified and Comparative Study of Edge Detection Algorithms, Proceedings of the International Conference on Information Technology: Coding and Computing (ITCC'02) 0-7695-1506-1/02 $17.00 © 2002 IEEE.

[15]. Andreas Koschan and Mongi Abid, Detection and Classification of Edges in Color Images, IEEE Signal Processing Magazine [65] January 2005.

[16]. Ehsan Nadernejad, Sara Sharifzadeh, Hamid Hassanpour, Edge Detection Techniques: Evaluations and Comparisons, Applied Mathematical Sciences, Vol. 2, 2008, no. 31, 1507 – 1520.

[17]. Li Jing, Huang Peikang, Wang Xiaohu & Pan Xudong, Image Edge Detection Based On Beamlet Transform, Journal of Systems Engineering and Electronics Vol. 20, No. 1, 2009, pp. 1-5.

[18]. Anand Gupta Ravi Kumar Dalal,Rahul Gupta,Pulkit Wadhwa, DGW-Canny: An Improvised Version Of Canny Edge Detector, 2011 International Symposium on Intelligent Signal Processing and Communication Systems (ISPACS) December 7-9, 2011.

[19]. G.T. Shrivakshan, Dr.C. Chandrasekar, A Comparison of various Edge Detection Techniques used in Image Processing, IJCSI International Journal of Computer Science Issues, Vol. 9, Issue 5, No 1, September 2012 ISSN (Online): 1694-0814.

[20]. Wenlong Fu, Mark Johnston, and Mengjie Zhang, Low-Level Feature Extraction for Edge Detection Using Genetic Programming, IEEE TRANSACTIONS ON CYBERNETICS, VOL. 44, NO. 8, AUGUST 2014 1459.

[21]. Chong Yu, Yonghong Song ✉, Quan Meng, Yuanlin Zhang, Yang Liu, Text detection and recognition in natural scene with edge analysis, IET Comput. Vis., 2015, Vol. 9, Iss. 4, pp. 603–613.

[22]. Gonzalez R, Woods R, Eddins S., Digital Image Processing Using MATLAB, Tata McGraw Hill Education Pvt. Ltd: New York,2010.

[23]. Naveen Singh Dagar, Pawan Kumar Dahiya, Soft Computing Techniques for Edge Detection Problem: A state-of-the-art Review, International Journal of Computer Applications (0975 – 8887) Volume 136 – No.12, February 2016.

AUTHOR'S PROFILES

Naveen Singh Dagar received his M.Tech (Electronics & Communication) from Deenbandhu Chhotu Ram University of Science & Technology, Murthal, Sonepat, Haryana, India. Currently, he is research scholar at Deenbandhu Chhotu Ram University of Science & Technology, Murthal, Sonepat, Haryana, India. His research includes Soft Computing Techniques for Edge Detection.

Pawan Kumar Dahiya has completed his PhD (Electronics & Communication) from Deenbandhu Chhotu Ram University of Science & Technology, Murthal, Sonepat, Haryana, India. Since 2002 he is working as Assistant Professor in Electronics & Communication Engineering Department in Deenbandhu Chhotu Ram University of Science & Technology, Murthal, Sonepat, Haryana, India. His areas of interset are Digital and Embedded System Design, ANPR, VANETs, Soft Computing Techniques. He has published more than 35 research publications in various journals, international and national conferences. He has supervised more than 27 M.Tech Dissertations. Presently, seven scholars are pursuing PhD under his supervision.