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A Review and Performance Analysis of Image Edge Detection Algorithms

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***Abstract*—** Edge detection is the fundamental operation of digital image processing and applied in many fields like industrial, medical, satellite, agriculture etc. According to this growth of edge detection applications, many researchers and scholars are interested to develop the edge detection algorithm by using various techniques. This paper illustrates the review for what are the novel techniques are used for the edge detection, which operators are mostly used by them and how they get the accurate results to compare with existing methods. It also discussing the performance analysis of most commonly used edge detection operators such as Canny, Laplacian Gaussian (LoG), Sobel, Prewitt and Roberts,. Finally the accuracy, PSNR (Peak Signal to Noise Ratio) and execution time are tabulated and realize the most precious and fast computed edge detection method is uncovered.

***Keywords*-** *Image Processing, Edge Detection, Corneal Diseases*

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I. INTRODUCTION

Edge is a basic and important feature of an image. Detecting edges is one of the most important aspects in image processing. Edge detection is a vital step as it is a process of identifying and locating sharp discontinuities in an image, which is one of the most frequently used operations in image analysis, and there are possibly more methods and algorithms in the literature for detecting edges than any other single subject. If the edges of images could be recognized, all the objects can be found well planned and executed can be measured easily.

Edge detection is one of the most important feature detection problem in image processing. Edge detection is an essential step as it is a process of recognizing and detects the objects in an image and there are possibly more methods and algorithms. An edge is the borderline between an object and the background, i.e. visually the object is separated from the background. If the edges of images could be recognized, all the objects can be found well planned and executed can be measured easily. Basically, before the edge detection process the image is grayscale image is converted into binary image in the output.

Many algorithms and operators are proposed by researchers to detect the edges accurately. This work is the type of review article, which reviews the recent edge detection algorithms to reducing the limitations of existing methods. Then the survey on edge detection operators to find which the most used operator is and how it is used as an ideal operator in noise images to give the successive approximation results. And finally the performance of the edge detectors are analyzed with mathematical operations and discussed with results.

II. REVIEW OF LITERATURE

There are many proposals for image edge detecting techniques, which are very advancement to the existing methods. Here some proposed methods are tabulated and which type of operator is maximally used to those novel approaches are also presented. The operators are denoted as the following letters: (Canny- C, Sobel-S, Robert-R, LoG-L, Prewitt-P, Fuzzy-F, Edison-E, Wavelet Transform-W, SUSAN-Su, Rothwell-Rw, Hyperbolic Mask- HM and Mexican Hat Mask -MHM)

Table 1. Review of Literature

Used Technique to edge detection	Type of operators used	Comments
A Complex Network Approach [1]	S,P,R,C,L	Sobel Operator is the nearest accuracy to the proposed system
Based on Ant colony Optimization [2]	C,S,L,R	Execution time of Each operators is better than the proposed method
A high payload stenographic algorithm [3]	C,S,F	Fuzzy operator's PSNR value is better than other operators
By using Hyperbolic and Gaussian Masks [4]	C, HM, MHM	Hyperbolic edge detector is effective than others
By using Multi-direction Shear Transform [5]	W	Wavelet transform's Running Time is lesser than proposed method
Edge detection Method in DCT	S	Sobel operator in spatial domain is less capability

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domain [6]		than proposed method
Least squares support vector machine in a contour let HMT domain [7]	C,W,L	Execution time of Each operators is better than the proposed method

By Using White-Gaussian Noise [8]	R,S,P,L	The coordinate precision values are approximately equal to proposed method
LS-SVM-based edge detection [9]	C,S	The performance of proposed system is similar to the Canny detector
Learning based Robust Edge detection algorithm [10]	C,S	Execution time of both operators is better than the proposed method
Improve Sobel Edge Detector [11]	S,F	Proposed method is modified successfully by using fuzzy sets
A Bacterial Foraging Technique [12]	C,S,E, Su, Rw	Entropy value of proposed method is approximately similar to the others
A Novel particle swarm optimization approach [13]	C	The accuracy of the proposed system is higher than the canny operator
By using Area Operators [14]	C,L	Objective comparison of proposed method is approximately similar to the others
A survey on Various techniques [15]	S,P,R,C,L	The accuracy of Modified declivity edge detector is better than these operators
By Using Cellular automata [16]	S,P,R,C,L	CED algorithm detects directed and undirected edges than others
Data Fusion Technology [17]	C	The proposed algorithm is complex, when reducing the Gaussian noise
By using Quasi high-pass filter [18]	S,C,L	The proposed operator outperformed other operators
By using KPCA-SCF based on the kernel method [19]	S,P,R,L,C	Error rate of Sobel operator is very low when compared to the others
By using Sparse Banded filter Matrices [20]	S,P,R,C	The proposed method is inaccurate when compare to the Sobel, Canny operators
Fuzzy Cellular Automata transition function [21]	C,S,F	Fuzzy edge images are more precious than Canny and Sobel Operator
LoG-Sobel Method [23]	S,L	The effect of proposed algorithm is better and much quicker
Based on Anisotropic Diffusion-driven Process [24]	C,S,P,L	Edge similarity strength is measured and comparatively proposed method has highly similarities than others
Comparison of various techniques used in Image Processing [25]	S,P,C,L,R	Canny algorithm has the better performance than others
A Survey of Soft computing approaches [26]	S,P,C,L,R, F	The proposed fuzzy based method has more efficiency properties than others

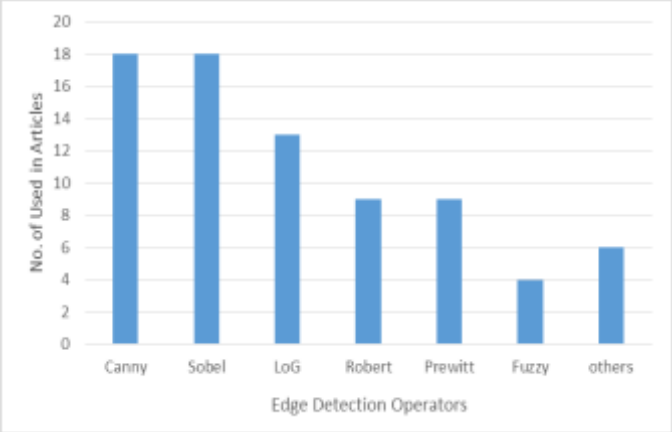

Figure 1. Edge detection operators and its number of used in articles

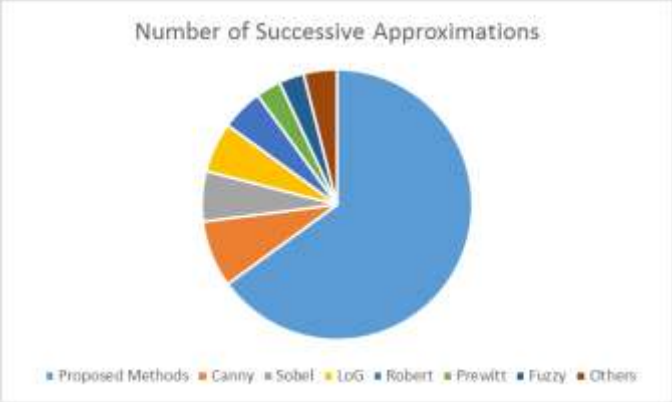

Figure 2. Number of successive approximations of edge detectors

From Table 1 and Figures1 & 2, Canny, Sobel, LoG, Robert, Prewitt are the most used edge detection operators for analyzing and compared with their proposed method. Most of the articles, their proposed method is only more accuracy than other operators. The Canny, Sobel operators are mainly produced accuracy only, not for time consumption. LoG and other operators, especially the fuzzy logic and neural network system are the growing proposals of edge detection techniques.

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III. PERFORMANCE ANALYSIS

The Performance analysis of the edge detection techniques is used to find out the better operator to detect the edges. For our research purpose, the corneal disease images are given as the input images, which are classified into five types. They are Age-related Macular Degeneration (AMD), Diabetic Macular Edema (DME), Retinal Vein Occlusion (RVO), Choroidal Neo Vascularization (CNV) and Pathologic Myopia (PM). These images are processed with edge detection operators (Sobel, Prewitt, Robert, LoG and Canny) to detect the edges as follows: (Figure 3 -7) and also the performance of those operators is analyzed with mathematical operations.

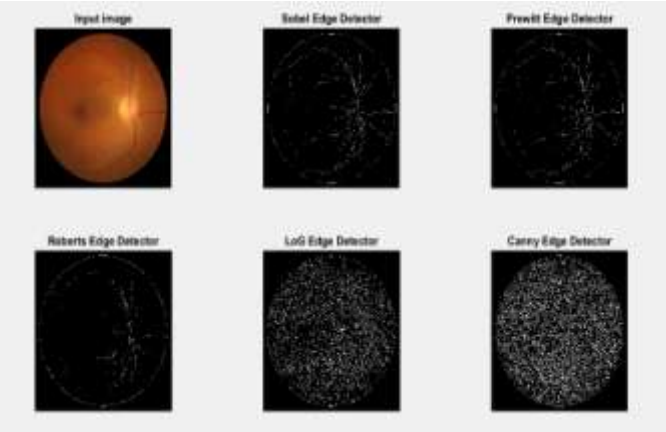

Figure 3. Age-related Macular Degeneration disease and its edges are detected

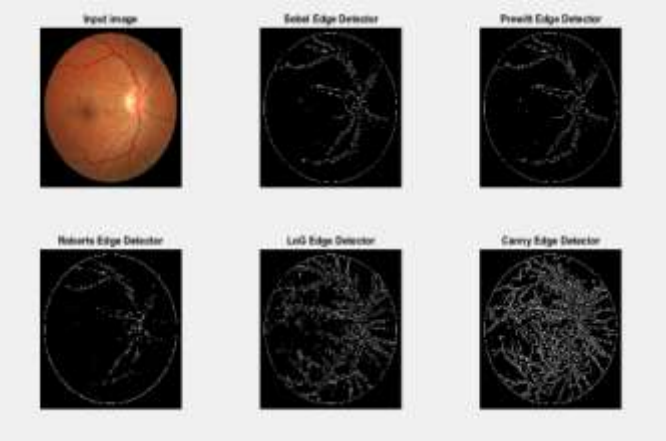

Figure 4. Diabetic Macular Edema disease and its edges are detected

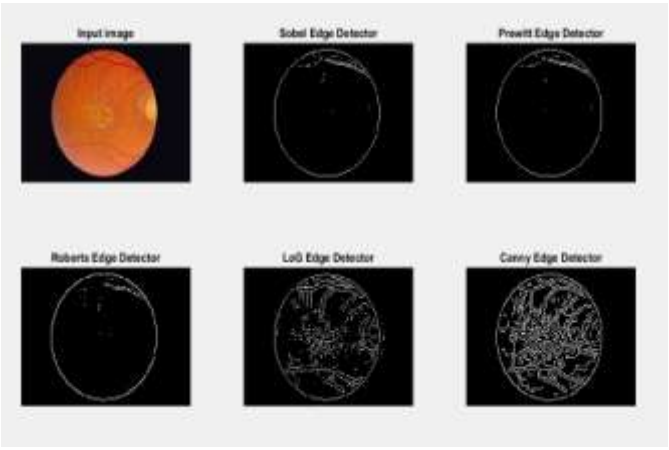

Figure 5. Retinal Vein Occlusion disease and its edges are detected

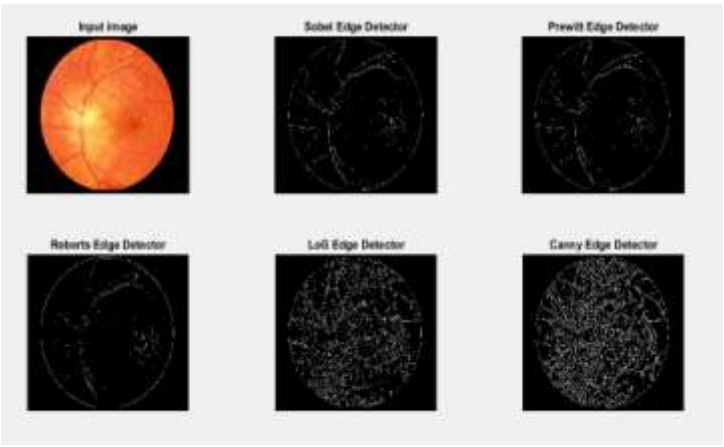

Figure 6. Choroidal Neo Vascularization disease and its edges are detected

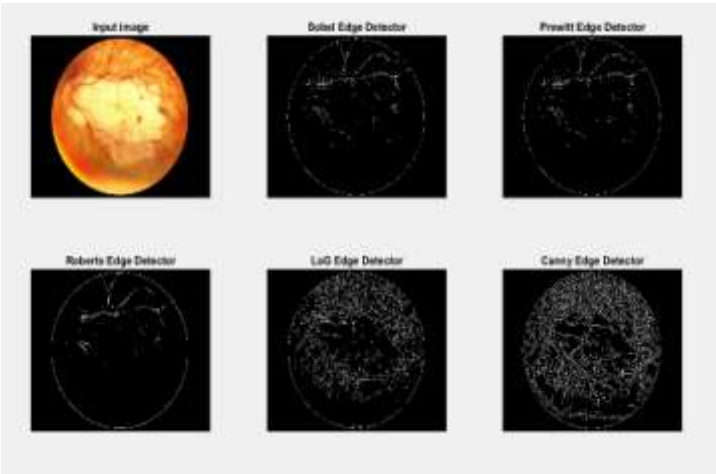

Figure 7. Pathologic Myopia disease and its edges are detected

The following mathematical operations are used to analyze the edge detection operator.

- Accuracy = $\frac{TP+TN}{TP+TN+FP+FN}$

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- Peak Signal to Noise Ratio (dB) =$10\ log_{10}\ \frac{(255)^2}{MSE}$
- Execution Time (sec) = Executed time – Starting Time

IV. RESULTS AND DISCUSSIONS

From the figures 8, 9, 10, the accuracy of the different edge detectors for various corneal diseases are illustrated. From these results the Sobel operator is less sensitive to noise and the canny operator having the highest accuracy level which is better detection in noise condition. Prewitt Operator has very low accuracy level when compare to the others, which states that Prewitt Operator is inaccurate to the noise. Robert operators have low accuracy level and highly susceptible to noise. The LoG operator is detecting the false edges in high probability. Canny operator is also reducing the probability of false and sharper edges.

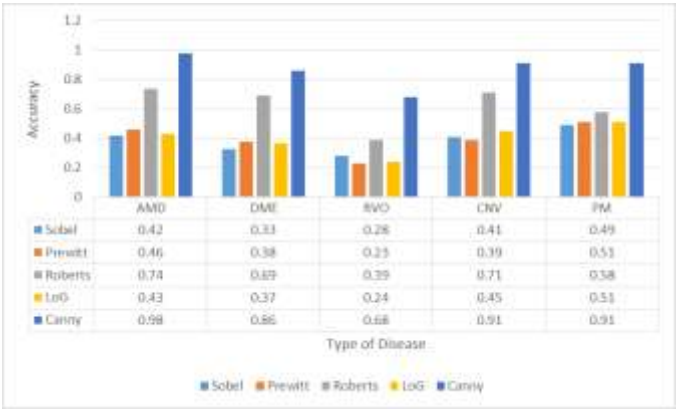

Figure 8. Calculation of Accuracy

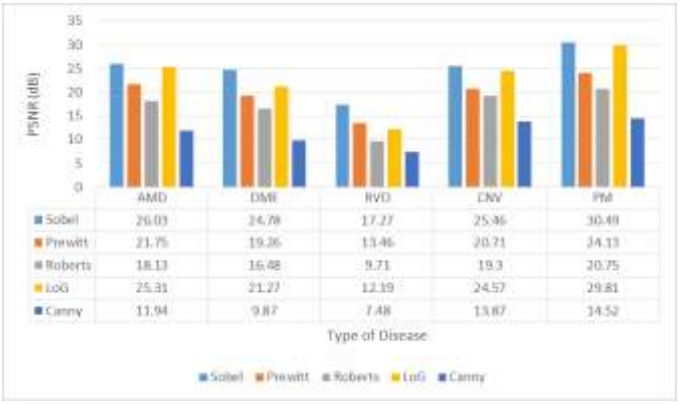

Figure 9. Calculation of PSNR

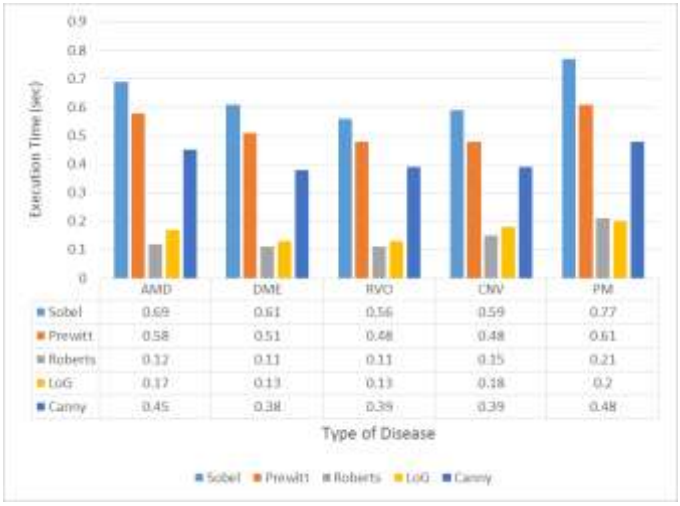

Figure 10. Calculation of Execution Time

Canny Edge detectors are having the improved signal to noise ratio value. At the same time, it is difficult to give a generic threshold that works well on all images. When compared with the canny operator, LoG operators having the better values but Sobel operator has less reliable in signal to nose ratio. Prewitt and Robert operators are maintain the average levels between Canny and LoG operators. In the LoG operator, the characteristics are fixed in all directions, so that its detection of edges and their orientation is simple. As the view of Execution time, the Robert operator is computed quickly than others. As a contradiction, canny edge detectors are Greater computational complexity operator and which consumes more time.

V. CONCLUSION

The main objective of this paper is to present a review of various approaches for image edge detection algorithms. The performance analysis also presented to evaluate edge detection operators and their experimental results shows that canny yield best results but poor execution time. LoG, Sobel operators gives the more accuracy and Prewitt operator is quickly computed. The Values of accuracy, PSNR and execution time are calculated for various operators. Finally, the novel edge detection algorithms are reviewed and the performance of edge detective operators is analyzed.

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