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Automatic Diabetic Retinopathy Diagnosis using Sobel Edge Detection from Fundus Imaging

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***Abstract*— In the era of image processing various diseases can be diagnosed automatically without any human intervention. A symptomatic disease can be recognized either of the imaging techniques such as X-Ray, CT Scan, Fundus imaging and MRI using various approaches present in the field of digital image processing. Diabetic Retinopathy is a symptomatic disease which is very dangerous because it leads to permanent blindness that cannot be cured. But routine checkup can save their vision that can be done under proper scanning and observation. It may cause due to diabetes and most of the cases pertained due to long diabetic duration. Here the proposed system is able to detect Diabetic Retinopathy automatically using Sobel edge detection technique and color mapping. Sobel is the best way to analyze the sensitive data by extracting the impairments in eyes or fundus imaging. Fundus imaging is a scanning technique for obtaining retinal image. System achieved 93% of accuracy which is bit higher than the previous works.**

***Keywords*— Automatic Diabetic Retinopathy Detection, Fundus Imaging, Optic Disc, Optic Cup, CNN, Retinal Image, Hemorrhages.**

I. INTRODUCTION

Diabetic retinopathy is a condition in which the blood vessels of the retina are damaged in people with diabetes. Diabetic retinopathy can develop if you have type 1 or 2 diabetes and uncontrolled high blood sugar levels. You may only start having mild vision problems, but eventually you will lose your focus. According to the National Eye Institute, untreated diabetic retinopathy is the most common cause of blindness in India. It is a very common eye disease in people with diabetes.

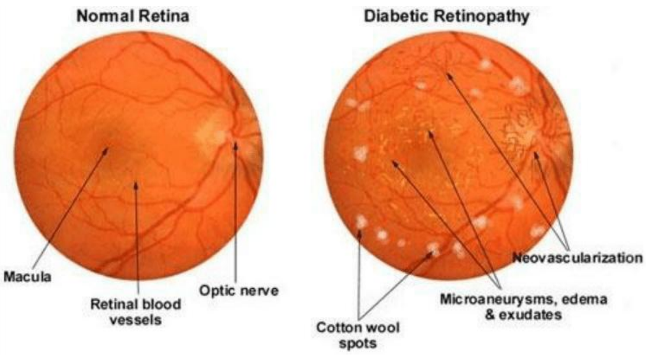

Fig. 1. Impairments over Ratinal Image [1]

The structure of the blood vessels in the retina of the eye provides information about the changes that occur after these retinal related eye diseases. Vascular, fova and optic disc (OD) are used to diagnose certain eye symptoms, such as diabetic retinopathy (DR) and other eye diseases. Many screening tools can be accessed to determine DR manually. According to clinical reports, more than ten percent of patients with diabetes have an increased risk of eye problems. Diabetic retinopathy (DR) is an eye disease that has been affecting eighty to eighty-five percent of diabetics for more than ten years. Retinal fundus images are commonly used in clinics to diagnose and diagnose diabetic retinopathy. Raw Retina Funds images are very difficult to process using a machine learning algorithm. In this paper, raw channel funding pre-processes images using color channel extraction, edge detection, image strengthening and resizing techniques. Experiments are performed using the Sobel edge detection technique for Diabetic Retinopathy Dataset and the results are evaluated based on the true positive, false positive, true negative and false negative for the collected symptoms [1].

Fig. 2. Diabetic Retinopathy vision loss [2]

The structure of the blood vessels in the retina of the eye provides information about the changes that occur after these retinal related eye diseases. Vascular vascular, fova and optic disc (OD) are used to diagnose certain eye symptoms, such as diabetic retinopathy (DR) and other eye diseases. Many screening tools can be accessed to determine DR manually. Digital fundus cameras are used to take pictures of retinal vessels; Therefore, unwanted brightness, environment and fundus image acquisition process can degrade the image quality somewhat. So image enhancement is always necessary to improve the desired image quality. Researchers suggest some methods to improve the quality of retina images. Some image processing methods used by researchers to diagnose eye diseases, including image enhancement, fragmentation, feature extraction and classification. Image recording is used to detect changes in medical images. Different images taken from different angles are arranged in a single coordinate system for successful registration. Image fusion is used to combine different types of information from different images into a single image. Separation is used to divide an image into multiple areas based on color, intensity, and objects. Image classification is used to label a group of pixels based on gray values or other parameters. Image analysis is used to easily understand the content of an image.

II. RELATED WORKS

A. Related Works

KK Palavalasa et al. [3] et al. proposed a new method to detect hard exudates with high accuracy relative to the level of injury. In the present method, we first identified candidate exudates lesions using the background ground reduction method. Following the next steps, in the final step of the algorithm, we removed the false exudates lesion results using the de-correlation stretch based method. We tested our algorithm in the publicly available DirectDB database, which contains the basic truth of all images. Compared to current art techniques, we have achieved high performance results for hard exudates lesion level detection with a sensitivity of 0.87, a F7 score of 0.78 and a positive rating of 0.76 (PPV). Ravishankar et.al. [4] proposed a new method to locate the optic disc, where they first identified the major blood vessels and used their division to determine the approximate location of the optic disc. Blurred C-Media Clustering tested several classifiers, including SVM, neural networks, PCA, and general Bayesian classification. Refers to the new control to identify the optic disc, where the major blood vessels are located and the approximate position of the optic disc using their division. It is further localized using color features. We show that many features such as blood vessels, exudates, micro aneurysms and bleeding can be accurately identified with various mutations that are appropriately applied.

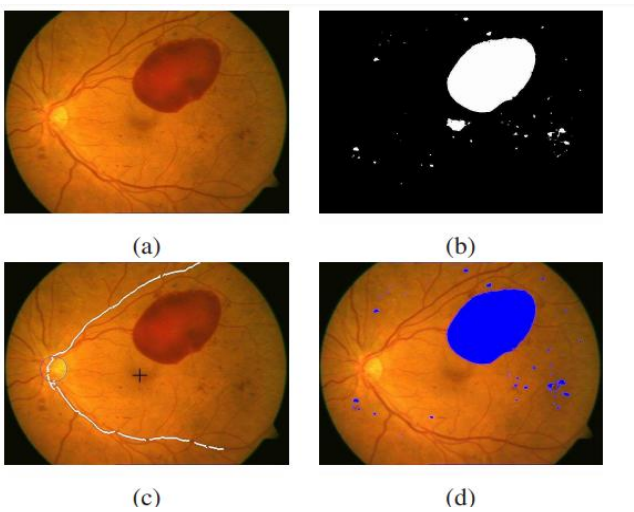

Fig. 3. Illustration of the steps of our Microaneurysms and Hemorrhages : (a) An image from dataset, (b) The image R obtained after morphological filling, (c) Fovea detection marked with '+', the main blood vessel, (d) The final result after removing fovea [4]

GG Gardener et al. [5] used a back propagation neural network. Exudates area, vascular area, hemorrhage, edema and microanurism area were selected for identification. This was done by analyzing images of one hundred and forty-seven patients with DR and thirty normal retinal images with exudates, retinal images with bleeding or microanurism, retinal images with no blood vessels, and retinal images containing blood vessels. The resulting specificity and sensitivity values are 88.4 and 83.5, respectively. Alireza et al. [6] proposed a partition based on the color representation of the Loves color space and its integration with the best partition using Fuse C-Medium (FCM) clustering. They used retina color information for our goals and showed progress through gray scale based technologies. FCM clustering gave an accuracy of 85.6%, a sensitivity value of 97.2 and a specificity of 85.4. A. Mukherjee et al. [7] proposed a supervised learning method to divide a given set of images into 5 classes. Various image processing methods and terslters improve many important features, such as the neural use for classification and the automatic, adaptive and innovative approach to image processing and the retina damage that can be easily detected at an early stage. M.W.Khan et al. [8] proposed a work of using several image processing techniques for DR injury detection. Early diagnosis of DR has been found to reduce the risk of vision loss by up to 50%. The image processing methods discussed in this paper can accurately identify DR. The hybrid method should be used to get the best results considering the accuracy and efficiency of DR identification. The various legion detection methods used for DR also give appropriate results. Image processing methods are evaluated based on these results.

III. PROBLEM IDENTIFICATION

System uses background and foreground subtraction for masking the unwanted background. It also uses thresholding for segmentation that segments blood vessels by converting it into binary image. But if eliminating or masking has been done using binarization or black and white intensities value then sensitive information may also erode or eliminate from image that may degrade the correct recognition rate. Back ground region of the fundus is the portion of the image where no retinal anatomy or lesions present, it consists of only the retinal layer of the fundus so it is an unwanted portion of the fundus image for screening of the DR. The detection of any anatomy or lesion present on the fundus image becomes simple, if it can detect and subtract the back ground region from the fundus image. By removal of back ground information we are left with only the retinal anatomy and lesions on the fore ground image of the fundus.

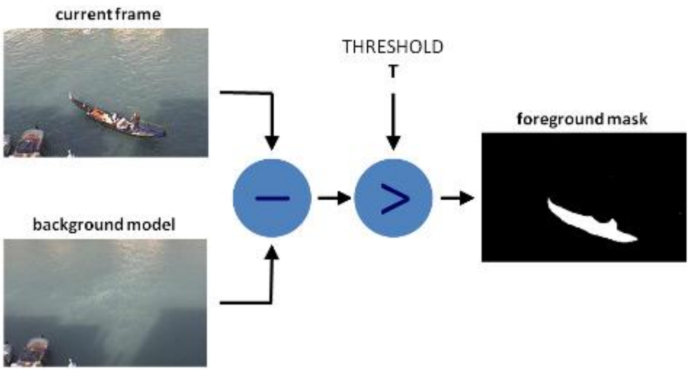

Fig. 4. Background Subtraction [12]

A major task in the field of computer vision and image processing is to detect the foreground and detect changes in image sequences. Background minimization is any technique that allows you to take the front of the image for further processing (image recognition, etc.). Most applications do not require information about the evolution of motion in a video sequence, but only information about changes in the scene, because the areas of interest on an image are objects in front of it (humans, cars, text, etc.). Object localization is required after the image preprocessing phase (which may include post-processing such as image denominating and syntax) that can use this technology. Based on these changes in the foreground, spotting the foreground separates the background from the background. These are techniques that analyze video footage recorded live with a still camera. It works well for object recognition from a general background that does not have complex features. It does not work effectively when it contains useful information in the background, such as blood vessels or nerves that are directly proportional to the accuracy of the system. Diabetic retinopathy requires in-depth monitoring to make a proper diagnosis with prudence and a high level of accuracy in the blood vessels. Diabetic retinopathy is a disease of the retina that affects diabetics and is a leading cause of blindness. It is a disease in which the blood vessels in the retina swell. It can damage the retina of the eye and lead to blindness if the level of diabetes is too high. Diabetic retinopathy affects 80% of people with diabetes for 20 years or more.

With proper treatment and eye monitoring, at least 90% of new cases can be reduced. The more diabetic a person is, the more likely they are to develop diabetic retinopathy. It is a leading cause of blindness in people between the ages of 20 and 64 years. The most effective treatment for the prevention of these eye diseases is early detection by regularly testing the fundus to identify the early symptoms of diabetic retinopathy. The digital fundus camera in ophthalmology gives us digitized data, which can be used to automatically diagnose the disease. Diabetic retinopathy is an eye disease that causes partial or complete loss of vision. Examining these images automatically will help doctors to more accurately diagnose the patient's condition. It emphasizes the determination of retina images using appropriate image processing and data mining techniques.

IV. PROPOSED WORK

Proposed work is able to detect Diabetic Retinopathy with less processing time using Sobel edge detection and color scaling technique. Color scaling is a new approach for classifying impairments in an image and changes get more highlightened. Sobel edge detection is gradient edge detection technique that works with horizontally and vertically. Sobel extracts the edges separately from horizontal traversing and vertical traversing then combined both the extractions. It targets sensitive edges and color mapping shows the impairments more precisely. There are various edge detection techniques but sobel is highly senstive and modern in use as compare to the canny, prewitt and roberts. It works with the kernel for both horizontal and vertical approach. Sobel has various kernels as per the directional ratio and whichever be required can be applied accordingly. The most common kernels are –

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

Fig 5. Horizontal Kernel

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

Fig 6. Vertical Kernel

It has been denoted as G_x and calculation can be performed as –

b11 = a11*1+a12*0+a13*(-1)+a21*2+a22*0+ a23*(-2)+ a31*1+ a32*0+ a33*(-1)

It has been denoted as G_y and calculation can be performed as –

b11 = a11*1+a21*0+a31*(-1)+a12*2+a22*0+ a32*(-2)+ a13*1+ a23*0+ a33*(-1)

After computation a gradient magnitude will be computed using –

$$G = \sqrt{G_x^2 + G_y^2}$$

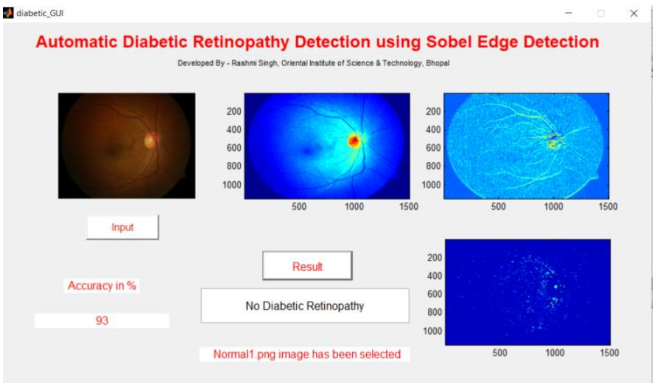

Fig. 5. Proposed Work GUI

System pertains the image for color corection and then sobel extract the edges and spots or impairments can be observed and detected effectively. Let it be more precise with the flow chart of the system. First of all system will acquired the fundus image then color scaling will be applied for color correction and image enhancement for better visibility. Then sobel will be applied for extracting edges from enhanced image and then compute the entropy value that will be compared with the threshold value. If computed value is greater than the threshold value then it is consider as Diabetic Retinopathy affected image otherwise declared as normal one.

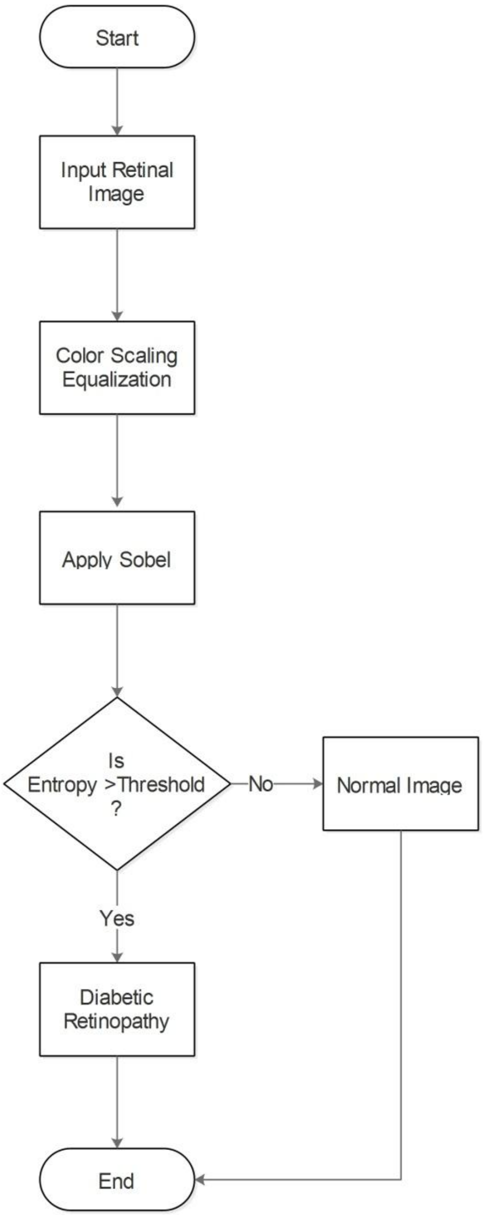

Fig. 6. Proposed Work Flow Chart

Sobel Gradient Algorithm-

Require: G_y ← Vertical Mask, G_x ← Horizontal mask , (x, y) ← coordinates, G ← Gradient magnitude, A ← Input Fundus image, T_r is a threshold
INPUT: A ← Input sign image as 2D matrix or array

OUTPUT: H ← Gradient magnitude

Step 1: Input 2-dimentional image as array

Step 2: Apply color scale mapping

Step 3: Adjust contrast using color histogram equalization

$$cdf_x(i) = \sum_j^0 P_x(j)$$

where cdf is cumulative distribution function, x is grayscale image, i is gray levels and P is probability

Step 4: Apply Sobel using kernel mask as G_x & G_y, where G_x is horizontal kernel mask & G_y as vertical kernel mask.

$$G_x = \begin{bmatrix} +1 & 0 & -1 \\ +2 & 0 & -2 \\ +1 & 0 & -1 \end{bmatrix} * A, \quad G_y = \begin{bmatrix} +1 & +2 & +1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix} * A$$

$$G = \sqrt{G_x^2 + G_y^2}$$

Step 5: Compute Entropy

$$(x, y) \rightarrow \left(\frac{1}{2} \times x, \frac{1}{2} \times y\right)$$

Step 6: if Entropy > T_r **then**

Diabetic Retinopathy;

else

Normal Fundus Image;

end else

end if

Step 7: End

V. RESULT ANALYSIS

The system has been tested with 100 OCT scanned fundus images of eyes of different patients that belong to infected traits or may not. System recorded 47 as true positive it means that there are 47 images contains diabetic retinopathy and system detected it positively and 3 as true negative that means there is an image contains diabetic retinopathy but system was not able to detect it. There are 46 tests are false negative where diabetic retinopathy has not been there and system didn't detect it as diabetic retinopathy and 4 as false positive where system detected a normal image as diabetic retinopathy which is an error rate of false detection that possess the system for degrading accuracy to 93.00 %.

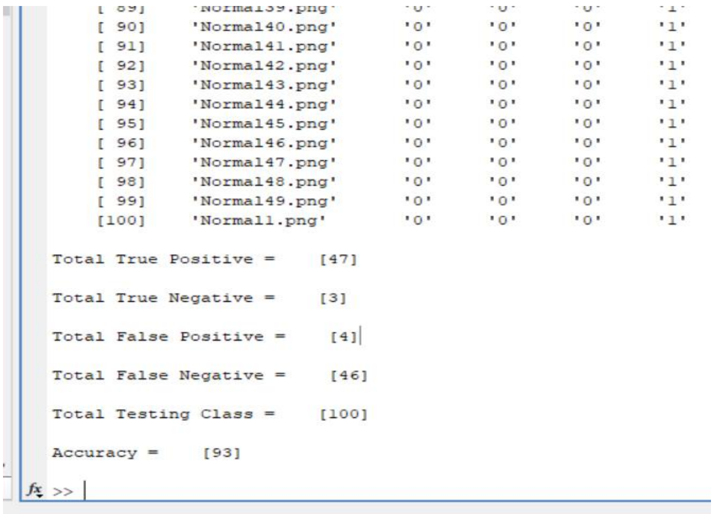

Fig. 7. Console Result

Accuracy = $\frac{TP+TN}{TTC} * 100$ %

Table No. I Result Analysis

	Outcomes	**Result (Accuracy)**
True Positive	47	94.00%
True Negative	3	0.60%
False Positive	4	0.80 %
False Negative	46	92.00 %
Total Testing Class	100	93.00 %

Table No. II Result Comparison

	Kranthi Kumar et al. [3]	**Proposed**
Modality	OCT	OCT
Method	Background and Foreground Subtraction	Sobel, Color Scale Mapping
Total Fundus Images	89	100
Result (Accuracy)	87.00 %	93.00 %

VI. CONCLUSION & FUTURE SCOPE

Automatic diabetic retinopathy detection provides the best solution to the difficulties and shortcomings of the current manual approach to detecting diabetic retinopathy with the naked human eye, which is time consuming and requires more effort and human resources with expert level knowledge and experience. System uses Sobel edge detection technique for extracting edges more precisely and effectively. System also uses color scale mapping technique for color correction and image enhancement for better visibility. System diagnoses diabetic retinopathy with high level of accuracy with less false acceptance rate. System recorded 93.00% of accuracy by testing 100 fundus images where 50 as positive cases and 50 as normal cases.

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