Automatic Diabetic Retinopathy Diagnosis using Prewitt Edge Detection & Color Mapping from Fundus Imaging

Megha Deshmukh, Vineeta Saxena Nigam

Abstract*: Diabetic Retinopathy is a diabetic disease that directly affects the vision that causes damaged blood vessels at the back end of the eyes. It a complicated disease that cannot be recognized from normal eyes; a fundus imaging can reflect the impairments over the retina that causes partial or complete blindness that cannot be cured. It is mandatory for a routine examination that may lead to prevent from complete blindness because it can be prevented from current damaged blood vessels but it cannot be revert or treated. In the field of image processing; various diseases can be diagnosed automatically that saves humans life along with easiness for medical professionals. If a person pertains diabetes for a long time may have highest possibility for diabetic retinopathy. Here, the system has been proposed that can diagnose this disease with high level of accuracy with minimal false alarm rate. System uses Prewitt Edge Detection and Color Mapping techniques for recognizing diabetic retinopathy symptoms or damaged blood vessels from fundus imaging. Prewitt is highly sensitive for extracting impairments along with blood vessels and system is able to mask the unwanted area by using color correction tool.

Keywords* : Automatic Diabetic Retinopathy Detection, Fundus Imaging, Optic Disc, Optic Cup, Prewitt Edge Detection, Color Mapping, Retinal Image, Hemorrhages.

I. INTRODUCTION

Diabetic retinopathy (DR) is a situation where blood vessels get damaged and blockage pertained that does not allow vessels to proper blood circulation over retina. If a person has uncontrolled blood sugar levels may have possibility to get blocked blood vessels. It may cause mild vision related problem but it may also pertain complete blindness. According to the National Eye Institute, India, untreated diabetic retinopathy is the most common cause for blindness in India. But people are not aware of this disease and they do not possess routine examination. Fig. 1 shows the exudates of diabetic retinopathy and haemorrhages. Retinal image is complex and hard to examine that is why it becomes challenges for extracting the impairments. Diabetic retinopathy (DR) is a main source of vision loss worldwide.

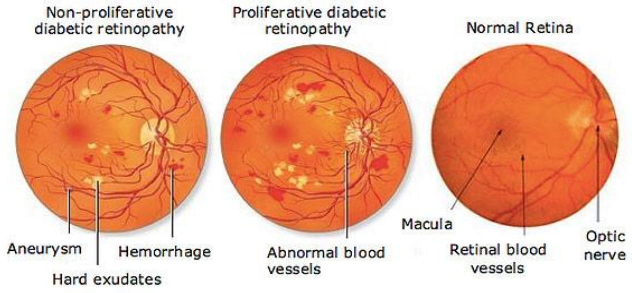

Fig. 1.Impairments over Ratinal Image [1]

It is quite possibly the most widely recognized reasons for preventable visual impairment. A meta-examination including 35 investigations overall assessed the worldwide commonness of DR among diabetes patients to be 7.62%–47.1%. The seriousness of DR can be separated into two phases as non-proliferative diabetic retinopathy (NPDR) and proliferative diabetic retinopathy (PDR). NPDR can be partitioned into gentle, moderate and extreme. Gentle NPDR is a beginning phase with microaneurysm (MA) and speck/smudge hemorrhage (HA) happening. In the serious NPDR stage, a lot more MAs, HAs or venous beading (VB) happens. The PDR stage is the high level phase of DR. The critical pathologies are new strange veins that called neovascularization (NV), pre-retinal hemorrhages (PHs), vitreous hemorrhage (VH), and fibrous proliferation (FP), which is the reason for tractional retinal separation. Screening and diagnosing DR early can forestall visual deficiency in the diabetic patients. Along these lines, we developed a system that can screen and determine DR to have the pathology extraction by utilizing the advanced image processing algorithms [2].

Fig. 2.Diabetic Retinopathy vision loss [3]

There are several tools are available that can determine the diabetic retinopathy manually and digital fundus images are the best retinal images for obtaining the desired information.

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Pre-processing of fundus imaging is bit necessary enhancing the image quality for better recognition but sensitive information must not distorted because it may creates false alarm rate that is not consider as ideal result in the field of medical science. Researchers proposed many approaches for diagnosing the disease effectively but somehow systems do not pertain good accuracy with minimal error rate. Almost all systems involves histogram equalization, segmentation, feature extraction and classification. Images may have various parameters such as color, intensity, objects and unwanted area. An intelligent system is liable to eliminate the unwanted background by color balancing and impaired area can be classified effectively.

II. RELATED WORKS

K K Palavaslasa et al. [4] proposed a system which is based on background and foreground subtraction for extracting the exudates from fundus imaging. It based on segmentation method by comparing the foreground image i.e. diabetic retinopathy image and background image i.e. normal image. By the help of comparison; the impairments get highlighted and DR can be recognized on the basis of impairment density. But all patients may have distinct data and it could not be consider a background image except foreground. Foreground image is current data frame of input and background is the data of normal patient and if a person has diabetic retinopathy then he must not have any background image for subtraction and if foreground is compared with normal patient's image then false alarm may get generated. Meher Madhu et al. [5] proposed a system which is supposed as proficient and precise exudates extraction procedure for utilizing image preprocessing and mass location on retina images from fundus imaging. To accelerate illness discovery of diabetic retinopathy, on a size of 0 to 4; 0 (no DR), 1 (mellow DR), 2 (moderate DR), 3 (serious DR), 4 (proliferative DR) experimentation is acted in the proposed model. Different algorithms are used with the feature extraction and identified that Naive Bayes Classifier is most proficient contrasted with other classifiers with an accuracy of 83%. Classifying impaired cells may also cluster the normal blood vessels and normal hemorrhage. Narjes Karami et al. [6] proposed an algorithm for automatic recognition of diabetic retinopathy dependent on discriminative dictionary learning, which doesn't need any division and highlight determination. Subsequent to finding the best atoms of each class (utilizing K-SVD algorithm), the discriminative molecules of each class are acquired by eliminating normal particles which brings about explicit atoms for principle signs of DR, for example, microaneurysms and hard exudates in diabetic class. The classifier rule depends on the sparsity of atomic representation by chose particles of each class. The fundamental target of this paper is to segregate K-SVD algorithm for eye fundus characterization. Pranjali Kokare et al. [7] proposed a system which is based on novel wavelet for exudates identification in retinal images of patients with diabetic retinopathy. Exudates are quite possibly the most common lesion during beginning phases of Diabetic Retinopathy (DR). To identify exudates we have proposed a novel wavelet based technique. To check the exudates location execution, the proposed technique was assessed utilizing the standard DIARETDB0 database, which contains images. Shaily Agarwal et al. [8] introduced different past works done to build up the image screening and observing tool to identify the phases of DR that will automatically referred to ompthologists for examine the cases. In past researches, it was noticed that various researchers introduced the good outcome to build up the DR screening frameworks.

III. PROBLEM IDENTIFICATION

System has been implemented using background and foreground subtraction for identifying the impairments over the fundus imaging. It is a method of segmentation by thresholding that has the capability of classifying blood vessels by transforming the image into binary one. It directly compares the background image and foreground image and return results accordingly. In binarization sensitive information may also erode that directly increases the false alarm rate. Back ground region of the fundus image is the portion where no retinal anatomy presents, it consists of only the retinal layer of the fundus. The identification of any anatomy or lesion present over the fundus image becomes simple, if it can detect and subtract the background region from the fundus image where foreground image is the current input image where DR may pertains. But there is no particular pattern of normal image as well as diabetic retinopathy because if system consider a normal image of any patient as background image and foreground image as target patient then all feasibility gone wrong. If a person pertains DR then there is no background image for that patient and considering any other patient data as background then false alarm get sustain [4].

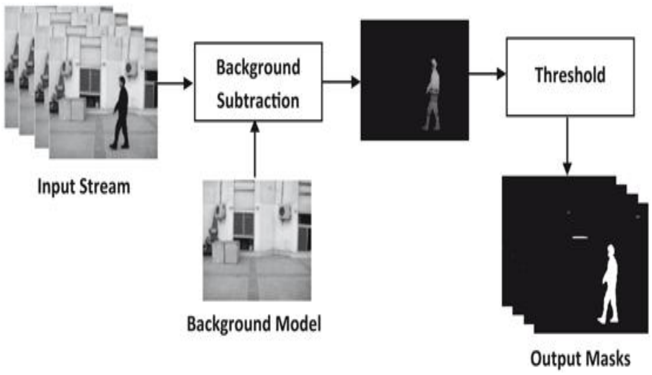

Fig. 3.Background Subtraction [9]

Background and foreground subtraction is a simple tool for computing the density of object over an image. As fig. 3 where there is a room with no pedestrian and that image is considered as background image and when any pedestrian appears that would be considered as foreground image and both images get compared with each other and when background image is subtracted with foreground image then foreground object remains visible and rest area been masked. So, this approach can be used for pedestrian detection or motion detection. But in the field of medical science when it's about to diagnose any disease with sensitive data extraction then this technique does not work effectively. A single patient data cannot be compared with the current patient input data.

IV. PROPOSED ARCHITECTURE

Proposed work is able to diagnose diabetic retinopathy automatically with less processing time. System can highlights the impairments over the diabetic retinopathy image and blood vessel can be masked easily by using color correction method and Prewitt edge detection operator. System has high proficiency to diagnose the diabetic retinopathy with minimal error rate. Color correction is a method of balancing colors by comparing the high intensity pixels with the threshold values. It is able to highlight the objects that image may contain and erode the background where unwanted area preserve. Once the pre-processing has been completed then system uses Prewitt edge detection for extracting edges vertically as well as horizontally then gradient magnitude of the traversed edges get combined and system attain the results where diabetic retinopathy impairments can be identified. Prewitt is a modern edge detection approach for sensitive edge extraction where inner edges are targeted.

A. Color Mapping

Color mapping is a technique that maps the colors of one (source) image to the colors of another (target) image. A color mapping might be alluded to as the calculation where outcomes are the changes the in the image colors. Color mapping is likewise in some cases called color transfer or color correction; it might likewise be called photometric camera calibration. Color calibration is a significant pre-processing task in computer vision applications. Numerous applications at the same time measure the images and colors to be adjusted. Instances of such applications are: image differencing, enlistment, object recognition, multi-camera monitoring and segmentation.

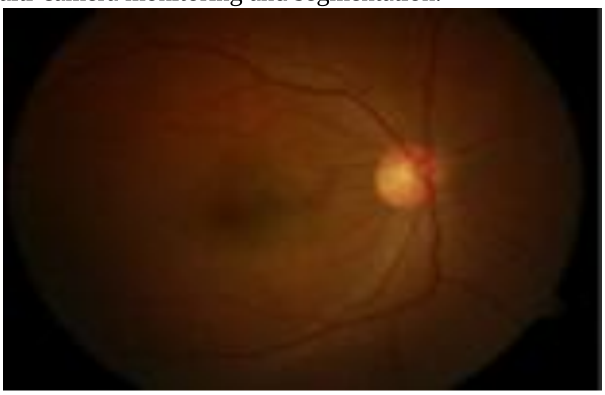

Fig. 4.Source Image

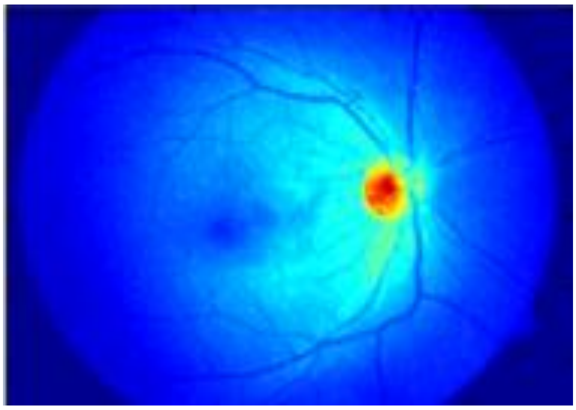

Fig. 5.Color Mapping of Source Image

B. Prewitt Edge Detection

Prewitt Operator is an edge detection technique where edges are to be extracted horizontally as well as vertically in a separate manner by using horizontal and vertical kernels. Prewitt has various kernels as per the directional ratio and whichever be required can be applied accordingly. The most common kernels are –

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

Fig. 6.Horizontal Kernel Mask

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

Fig. 7. Vertical Kernel Mask

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

A =

10	50	10	50	10
10	55	10	55	10
10	52	10	52	10
10	55	10	55	10
10	53	10	53	10

$$* \begin{cases} G_x \\ G_y \end{cases}$$

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

C. Flow Chart

As per the flow chart given below in fig. 8, first of all; system attains the fundus image which will be considered as the input image and color correction will be applied for image enhancement or color transformation for better visibility. Color correction adjusted the colors according to the objects specified in the image in the reference of background image. Then Prewitt edge detection is to be applied for extracting edges horizontally as well as vertically and the gradient magnitude of the Prewitt is to be computed for entropy estimation. Entropy is the density occupied by the impairments that will be compared with the threshold value. In Image, Entropy is characterized as relating conditions of intensity level which singular pixels can adjust.

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It is utilized in the quantitative examination and assessment image subtleties, the entropy esteem is utilized as it gives better correlation of the image subtleties. If computed entropy is greater than the threshold value; it means that particular fundus image contains Diabetic Retinopathy symptoms otherwise system will declared it as a normal fundus image where there is no diabetic retinopathy.

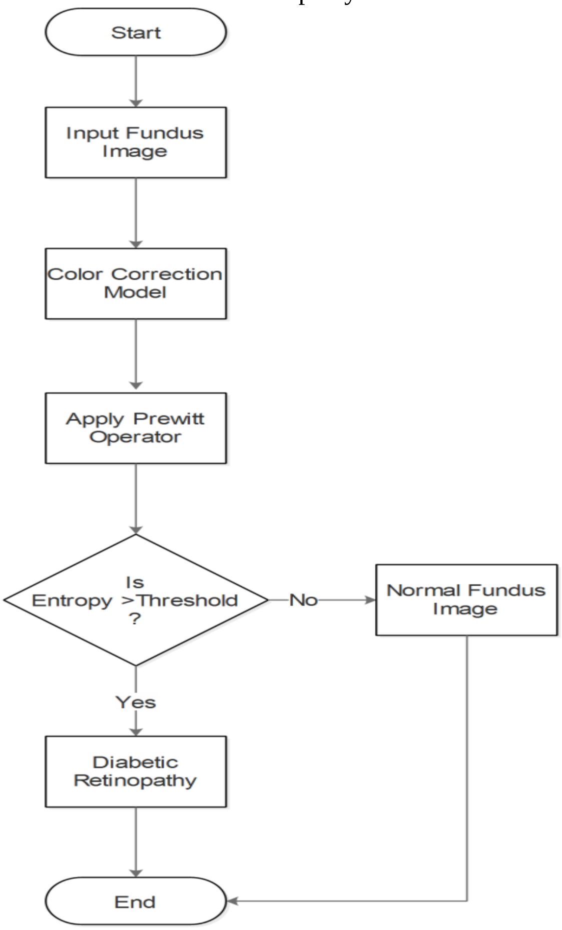

Fig. 8.Flow Chart of Proposed Work

D. Prewitt Gradient Kernel Algorithm-

Require: $G_x \leftarrow$ Horizontal kernel mask, $G_y \leftarrow$ Vertical kernel Mask, (x, y) $\leftarrow$ image coordinates, G $\leftarrow$ Absolute Gradient magnitude, A $\leftarrow$ Input Fundus image, $T_r \leftarrow$ threshold value

INPUT: A $\leftarrow$ Input fundus image as two dimensional matrix

OUTPUT: G $\leftarrow$ Absolute Gradient magnitude

Step 1: Input two dimensional fundus image matrix

Step 2: Apply color correction

Scalar value S_i range {min→max}

n is unique color, {color 0 ... color n-1 }

if S< min then C = $color_{min}$

else if S> max then C = $color_{max}$

Step 3: Apply Prewitt operator using kernel masks

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

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

Step 4: Compute Entropy

1. $$H = -\sum_{i=0}^{255} p_i$$

p_i is the probability associated with the graylevel i

Step 5: if H > T_r **then**

Diabetic Retinopathy;

else

Normal Fundus Image;

end else

end if

Step 6: End

V. RESULT ANALYSIS

Here the system has been validated with 110 OCT scanned fundus retinal images of different patients that may belong to infected traits or may not. As per the dataset; system recorded 53 as true positive that means there are 53 images belong to diabetic retinopathy and system identified it positively and 2 as true negative that means there is an image belongs to diabetic retinopathy nevertheless system was not able to detect it. There are 52 tests recorded as false negative where diabetic retinopathy does not exists and system didn't detect that disease and 3 as false positive where system identified a normal fundus image as diabetic retinopathy which is not correct or an error rate of false detection that possess the system for degrading accuracy to 95.45 %.

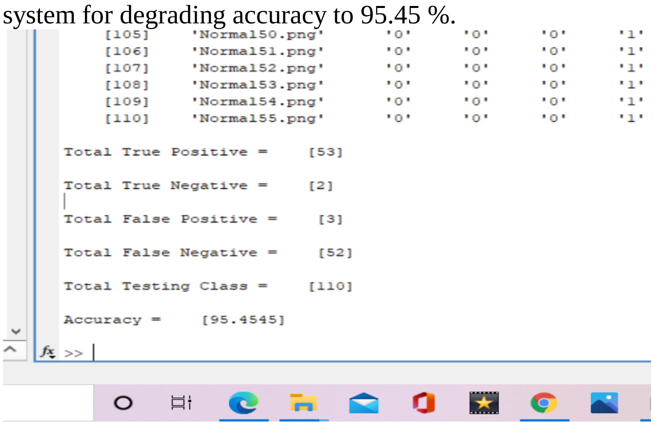

Fig. 9.Console Result

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

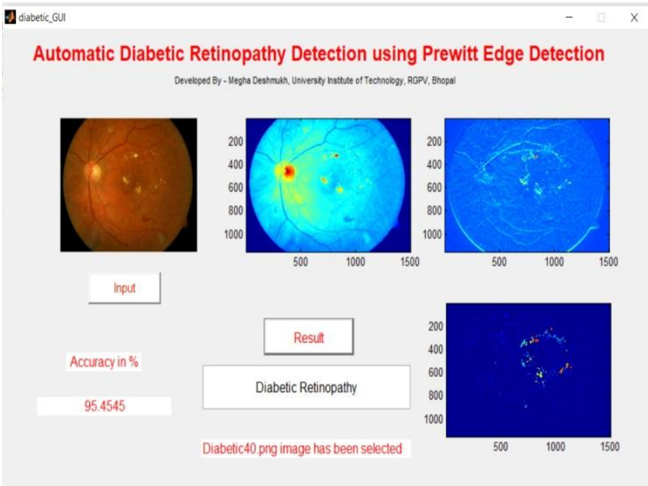

Fig. 10. GUI of Proposed Work

Table- I: Result Analysis

	Outcomes	Result (Accuracy)
True Positive	53	96.36%
True Negative	2	3.63%
False Positive	3	5.45 %
False Negative	52	94.54 %
Total Testing Class	110	95.45 %

Table- II: Result Comparison

	K. K. Palavalasa et al. [4]	Proposed
Modality	OCT	OCT
Method	Background & Foreground Subtraction	Color Mapping & Prewitt Operator
Total Fundus Images	89	110
Result (Accuracy)	87.00 %	95.45 %

VI. CONCLUSION & FUTURE SCOPE

Here the proposed system is able to classify the diabetic retinopathy impairments with high level of accuracy with minimal false alarm rate. Manually identifying any disease is a time consuming and requires medical practitioner's intervention. Automatic diabetic retinopathy detection is a modern approach for identifying eye related disease that requires a routine examination because it may cause partial or complete blindness that cannot be cured once affected. System uses Color Correction model for classifying the background and highlighted the high intensity areas. Prewitt operator extracts the edges horizontally and vertically for computing the absolute gradient magnitude of the matrix and identifying whether the fundus image pertains diabetic retinopathy or not. Image processing is a trend now that saves humans life as well as medical practitioner's efforts in the field of medical science.

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