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Morphological Based Approach for Identification of Red Lesion in Diabetic Retinopathy

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Abstract: One of the common causes of visionloss and blindness in patients with diabetes is Diabetic Retinopathy.The damage to the retina of human eye caused by the complication of increase in blood glucose level consequently leading to blindness is termed as Diabetic retinopathy. The longer the patient has diabetes the higher the chance of developing diabetic retinopathy [1].No specific symptoms are seen in DR patients until the illness is at the final stage. Thus , prior detection and timely treatment has to be ensured. Dark lesions such as Microaneurysms and Hemorrhages or bright lesions like Exudates are the visible symotoms of Diabetic Retinopathy [3]. Microaneurysms are reddish in color with a diameter less than 125 µm,which turn into hemorrhages at a later stage [6]. Conventionally , An ophthalmologist visualizes the blood vessels of the patient's brain using an ophthalmoscope . This method is often time consuming and requires fluorescein angiograms for precise diagnosis. Moreover , it also requires highly trained and skilled clinicians to perform the DR severity grading technique. Tis paper presents a low cost retinal algorithm for detecting microaneurysms and hemorrhages which will assist opthalmologists across the globe in timely detection of diabetic retinopathy.

Keywords: Diabetic retinopathy,diagnosis Ophthalmologist, fluorescein angiograms, Microaneurysms and Hemorrhages.

I. INTRODUCTION

Diabetes is a disease which occurs when the pancreas fail to secrete enough insulin or the body unable to process it properly. As diabetes progresses, the disease slowly affects the circulatory system including the retina of human eye and as a result of long term accumulated damage to blood vessels leads to decline in the vision of patient which is termed as diabetic retinopathy. Diabetic Retinopathy is termed as an eye disease that has the ability to cause partial or even complete visual impairment if left undetermined at the earlier stages. Retinal lesions associated with the diabetics are used to evaluate different stages and the severity of the diabetic retinopathy [1].

Due to modern living style, a list of people is getting affected with Diabetes. The World Health Organization evaluated that 135 million people have diabetes mellitus worldwide and the number of people with diabetes will increase to 300 million by the year 2025 [11]. Doctors recognize diabetic retinopathy by examining the features, such as blood vessel area, exudates, hemorrhages, microaneurysms and texture. Diabetic retinopathy can be divided into three stages of non-proliferative retinopathy: mild, moderate, and severe and one stage of proliferative retinopathy[12].
Different retinal features are blood vessels, optic disk,macula and fovea as shown in Fig. 1. Due to diabetic retinopathy different parts of the retina get damaged and lead to vision loss. Also the characteristics are changed due to different pathological conditions [13]. Due to changes in retinal features, new features such as microaneurysms, exudates, and hemorrhages appear in the retina as shown in Fig. 2. Diabetic Retinopathy is a frequent complication of diabetes and the most common cause of blindness in the working population of the western world.

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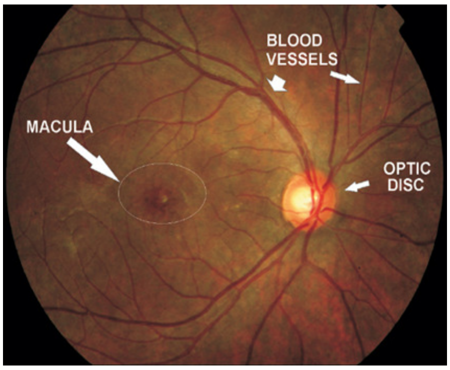


Fig. 1. Normal Retinal Fundus Image

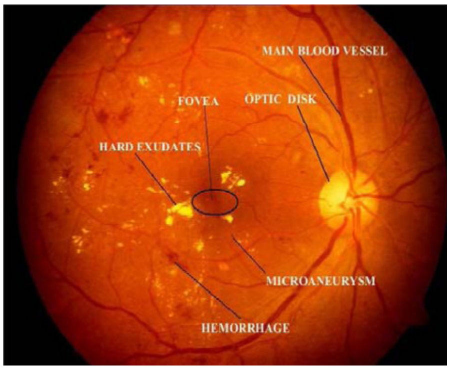
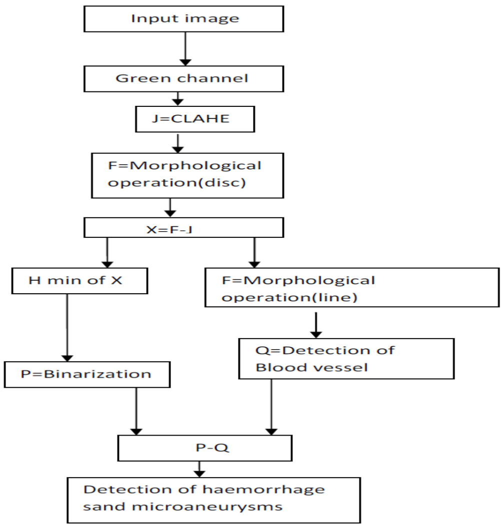


Fig. 2. Retinal Fundus Image Containing DR Lesions

One of the most important steps in the automated detection of DR is the detection of microaneurysms and Hemorrhages. Microaneurysms and Hemorrhages are amongst the earliest observable signs of the presence of diabetic retinopathy. Due to a large number of patients, the available ophthalmologists are not sufficient in handling all the patients, especially in rural areas [14]. Therefore, automated early detection of microaneurysms could ease the burden of ophthalmologists. Automated microaneurysms detection can also help the ophthalmologists in investigating and treating the disease more efficiently [15].

II. Proposed Methodology

Microaneurysms and Hemorrhages detection is carried out in the following stages.



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Step-1: Green channel
Green channel is extracted from the RGB color space,which has better contrast when compared to other channels.

Step-2 : J=CLAHE
Contrast-Limited Adaptive Histogram Equalization (CLAHE) is applied . This technique consists in applying histogram equalization for each region in the image, enhancing the local contrast of each region.

Step-3:F=Morphological operation(disc)
The purpose of this stage is an enhancement of the low intensity structures of the fundus images,and then use them as candidates for red lesions.
Morphological opening and closing is done on CLAHE image using structuring element with radius of 5 pixels.

Step-4 : X=F-J
Image of step 2 is subtracted from image of step 3 so high intensity structure will be eliminated.

Step-5 : H minima transform of X
This operator removes connected basins with contrast less than a threshold *h*, using for this purpose a morphological reconstruction based on erosion.

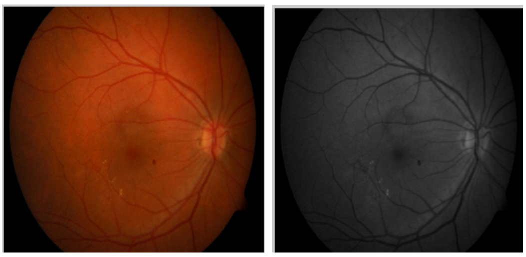
Step-6 : Binarization
Then image is binarized using the morphological operator of regional minimum *RMIN*. This operator converts a grayscale image to binary format without using any threshold, and is also based on morphological reconstruction by erosion.

Step-7 : Morphological operation (line)
the detection of the blood vessels was implemented using the morphological opening of image from step-4 with multi-scale structuring elements. The morphological opening is performed 12 times on the image, using linear structuring elements with 12 different angles, ranging 15 degrees to each structuring element (namely 0 °, 15°, 30 °, and so on up to 165 °). As the blood vessels have a linear and elongated geometric feature, the length of the structuring element was defined with the value 150 pixels.

Step 8 : Q=Detection of blood vessels
Finally, the 12 images obtained were added, getting the image , containing a sketch of the blood vessels the detection of the blood vessels was performed from a morphological reconstruction by dilation.

Step 9 : P-Q
Image from step 8 is subtracted from image of step 6.As a result we get haemorrhages and microaneurysms.

1. **Experimental Results**



(a) **(b)**

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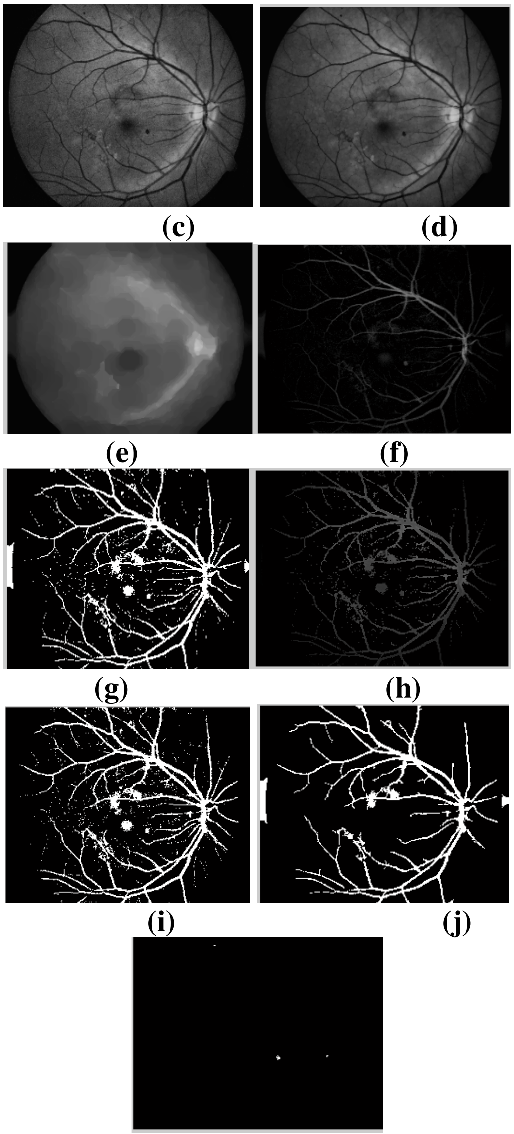

Figure 4.(a) original image, (b) green channel, (c) J=CLAHE, (d) Morphological opening,(e) F= Morphological closing,(f) X=F-J,(g) H min transform of X, (h) Enhancement of low intensity structure, (i) P=binarization, (j) Q=detection of blood vessels, (k) P-Q=detection of hemorrhages and microaneurysms.

Images	TP	FP	FN	TN	Sensitivity (%)	Specificity (%)	PPV (%)	Accuracy (%)
1	415	66	80	1727519	83.83	99.99	86.27	99.96
2	236	294	0	1727469	100	99.98	74.52	99.98
3	390	138	12	1727472	97.01	99.99	73.86	99.99
4	1885	573	937	1725541	66.79	99.96	76.68	99.91
5	6057	725	764	1721218	88.79	99.95	89.3	99.91
6	1624	436	208	1726542	88.64	99.89	78.88	99.84
7	3382	312	243	1727632	93.29	99.92	91.55	99.86

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III. Evalution and Performance Measure

The algorithms are implemented and the performance of each algorithm is measured by comparing the obtained results with the ophthalmologist's hand-drawn ground truth. Eight performance measurements, namely, True Positive (TP, a number of exudates pixels correctly detected), False Positive (FP, a number of non-exudate pixels which are detected wrongly as exudate pixels), False Negative (FN, a number of exudate pixels that are not detected), True Negative (TN, a number of non-exudates pixels which are correctly identified as non-exudate pixels), Sensitivity, Specificity, Positive Predictive Value (PPV), and Accuracy are calculated. Equations below show the computation of Sensitivity, Specificity, PPV (Positive Predicate Value) and Accuracy, respectively:

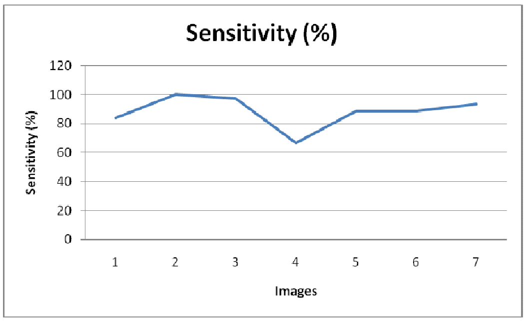
$$\text{Sensitivity} = \frac{TP}{TP + FN}$$

$$\text{Specificity} = \frac{TN}{TN + FP}$$

$$\text{PPV} = \frac{TP}{TP + FP}$$

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

Sensitivity is essentially how good a test is at finding something if it is there, means the proportion of actual positives which are correctly identified. Specificity is a measure against false positives, how accurate a test is, means the proportion of negatives which are correctly identified.



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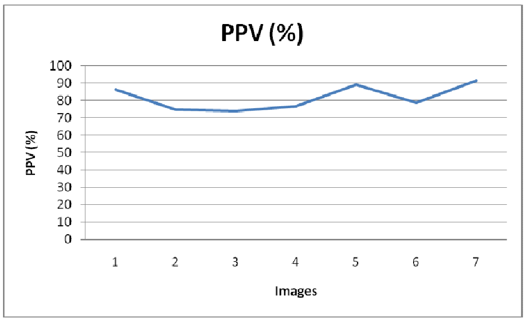

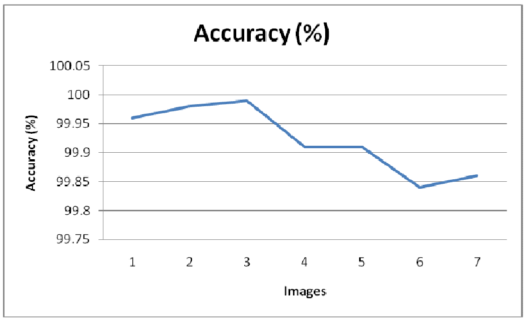

IV. CONCLUSION AND FUTURE WORK

Diabetes is a metabolic disease that affects tens of millions of people around the world. The statistics shows that this number of diabetic patients will double over the course of future years . Diabetic retinopathy is a sever disease that can multiply leave permanent consequences on the normal function of the human organism, one of them being negatively affecting visual function. Regular screenings and medical checkups along with adequate treatment can prevent the further development of the disease.

We proposed cost-effective algorithm for automated detection of hemorrhages and microaneurysms with the goal to assisting ophthalmologist/medical doctor in diagnostics procedures.

The scope of our future research is related to detection of cotton wool spot for detecting diabetic retinopathy caused by diabetes.

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