Optimizing Microaneurysm Detection for Early Diagnosis of Diabetic Retinopathy with Enhanced Fundus Images

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Abstract:

Diabetic Retinopathy (DR) stands as the primary cause of visual impairment among individuals in the workforce. Detecting it early through routine screenings and providing accurate treatment has proven effective in preventing vision loss. Fundus photography enables the capture of detailed images of the eye's interior. The automated identification of lesions offers a straightforward and economical approach. This technology aids doctors in decreasing their workload while enhancing accuracy and efficiency.

The focus of our research revolves around identifying red lesions, characterized by minuscule dots in fundus images. These dots signify the presence of microaneurysms, which represent an initial stage in diabetic retinopathy detection. Given that microaneurysms serve as symptomatic indicators of diabetic retinopathy, their identification holds crucial importance. Our approach is built upon a highly efficient level set framework, designed to effectively detect the presence of these lesions within the affected images.

The identification of microaneurysms proves effective through the recognition of red lesions within color fundus images. Our algorithm yields improved outcomes in both image enhancement and the detection of these small dot-like microaneurysms. The initial phase of our methodology involves extracting the grey channel, enhancing the image, and subsequently progressing to feature extraction, result computation, and a comparison between the resultant image and the ground truth image. Our efforts resulted in a sensitivity of 70.81%.

Keywords: Fundus, matched filter, microaneurysms, morphology, hemorrhages, retina

I. INTRODUCTION

Diabetic retinopathy (DR) is a common retinal complication linked with diabetes, causing significant blindness in both middle and advanced age groups. The National Diabetes Information data (US) reveals that out of the total 23.6 million people with diabetes, which accounts for 7.8 percent of the US population, only 17.9 million cases have been diagnosed. To prevent vision loss, early identification of the disease through consistent screening is of utmost importance. Given the necessity to screen a substantial population

frequently, an automated DR diagnostic system could play a vital role in streamlining this process. Ophthalmologists employ color fundus images to examine ocular conditions like diabetic retinopathy. Microaneurysms, appearing as small red dots, are small saccular pouches resulting from localized distension of capillary walls [1]. These can potentially lead to the formation of significant blood clots referred to as hemorrhages. Hard exudates, characterized by their bright yellow appearance, are deposits of yellow lipids. The optic disk, a bright circular area, serves as the point of origin for blood vessels. At the center of the retina lies the fovea, the region with the highest visual acuity. The distribution of exudates and microaneurysms in space is a key consideration.

The paper is organized as follows. In "Methodology" implementation details of the proposed algorithm are presented. In "Experimental Results and Discussion," experimental results are compared to existing methods. Conclusions are in the "Conclusions" section.
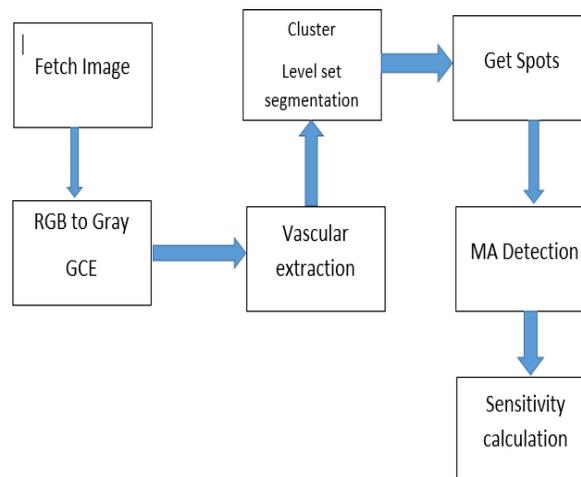
II. METHODOLOGY

Fig1. Block diagram of proposed method of MAdetection

A. RGB to Gray
In the RGB to Gray level conversion the original image is converted into the three forms. They are red, green and blue colors. We are selecting only the red and the green images. After selecting the images, we need to subtract the images and obtain matching images. In the Histogram matching images, we use the command as Mishits. The histogram matching obtains the brighter images which is called the gray scale images. In the gray scale images, we can separate the brighter part and the dark part of the image. After obtaining the gray scale image, we apply the median filtering to the image, here we obtain the brighter part of the image.

Figure 2.(a) Figure 2(b)

Figure 2: (a)Green image (b)Red Image

B. Vascular extraction

In the vascular tree extraction we followed different steps.Step 1: First find the edge of retina using Sobel method (edge.m)

Step 2: Select the disc shaped structure element

Step 3: Dilate the input image in order to expand thebright region and shrink the dark   region.

Step 4: Detect the width of the vessel.

Step 5: Apply the Morphological method (Dilationand Erosion)

Step 6: Extract the vascular tree.

The first method is the Sobel method. This method is applicable for the 2-D images and this method is mainly helpful for finding the edges of the images. In this method it uses the diffusion of the anti-scope lines ofthe images and the disconnected lines will be eliminated. The noise of image will be dilated and the vascular lines will be made as the thin lines to obtain the accuracy of theimages. The radius of each vessel is detected, noise of signal is eliminated and extract the exact output of the image.

Median filtering is applied to an image. This eliminates the dark shades and noise in the image. The image figure 2(a), figure 2(b) shows the green channel extraction and the red channel extraction.

And next, the subtraction of the images is performed and the obtained resultant image will be the histogram matching image. The median filtered image is shown in the figure 3 and the figure 4. Respectively.

Figure 3: Histogram Matching

Figure 4: Median Filtering

In the second step we need to select the disc shaped element. In that process we do the masking of the image. We will later compare the original image with the fundus image. Hence the exact location of the disc shaped image is marked/spotted and in that place the masking will be done.

The third step is the dilation process; hence we concentrate only on the vessels of the image. The other part will be dilated during this bright lesion will be extracted and the dark lesion will be shirked.

In the fourth step, we find the width of each vessel. And we apply the morphological method. In the morphological method, we apply structuring element to an input image creating an output image with the same size. The most of the morphological operation is based on dilation and the erosion.

Dilation - adds the pixels to the boundary of the objectives in the images.

Erosion - remove the pixels on the objective boundaries. The last step is the vascular tree extraction. In this we get the thin vessels and the background will be dark.

After Dilation and Erosion, the image will be dilated. The resultant image is the vascular tree. The vascular tree, extraction is done on binary images. The extracted vessels is shown in figure 5.
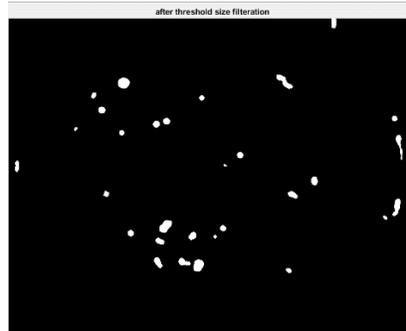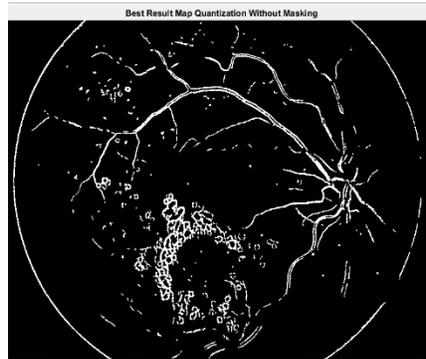

Figure 5: Vascular tree extraction

Figure 6: Level set Segmentation

C. Level set segmentation

The level set method is the conceptual analysis of the image, as numerical analysis of the image size and the shape of the image. The advanced method of the level set is the numerical computation will be involved in the curve and shape of the image. The analysis will be taken place as the xy-plane analysis.

The level set method will be applied to the counter method. The counter method indicates the image rotated in the V- shaped and later get the location of the image. The cluster level set segmentation is done to an image. The level set initially set the points to the images in the same way it will be differentiate the image. The image will be divide into different levels. In the process and we need to select the image with foreground image. The level set segmentation method which is shown in the figure 6.
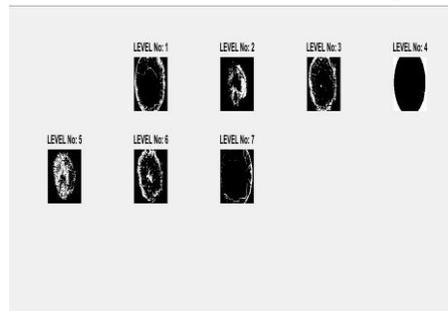

Figure 7: The MA and the Non Ma can be detected

D. Get spots

After level set segmentation we select an image which contain the MA, hemorrhages and exudates. Different levels we select an image which is white spots and black in background. We need to identify the MA in that. Identifying the spots is most tedious method. Because it contain more number of wanted and unwanted MA's. The spots identified are represented in the figure 7.

E. MA Detection

The main aim of the project is MA detection. The spotted image will be containing many unwanted features. In that we need to extract exact MA. The microaneurysm detection is based mainly on the gray scale image and morphological parameters. They are extracted based on area, circularity, perimeter and aspect meters.

The size of the main image will be dived into the major axis and the minor axis.

Major axis: the major axis is the ellipse passing on the foci. The scalar will be specifying the length of the image and second center movement of the axis.

Minor axis: the minor axis shows the line which is passing through the center of the ellipse. It reprints the width in the image. This is the normalized second center line in the region.

The aspect ratio can be calculated as the length to the width ratio of the retinal image. It can be defined as acceptratio=1/w. The region of ratio property will be based on Area, Eccentricity and the perimeter.

Area: The area is based on the actual number of pixels in the region.

Eccentricity: the eccentricity is the ratio of the distance between the ellipse and foci.

Perimeter: The computer calculate the distance between the adjacent pairs and the boundary region.

The intensity will be calculated using the MATLAB function. According to medical definition, MA are reddish in color and they are the less than the 125 micrometers. In this the boundaries of the image are highlighted.

Figure 5.11 indicates the location of the MA present in the image it also identify the area which is affected by MA's and is detected in figure 8 and figure 9 respectively.
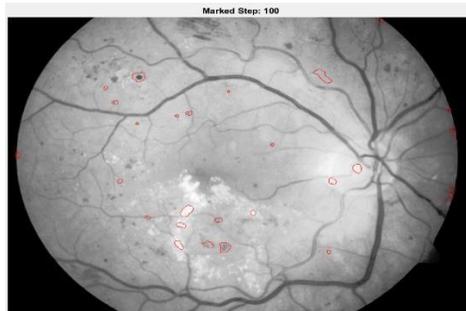

Figure 8: Marking the MA in the fundus image

Figure 9: Marking the MA in the exact location of the image

F. Sensitivity calculation

The data set of 30 images are calculated using the MATLAB. Each image will take around five minutes to process the image. The obtained image will be compared with the ground truth image and later we identify the points. Points which are in the exact location of an image. The true positive and false negative are referred from the selected image. Using the TP and FN we calculate the sensitivity of 30 images.

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

TP (True Positive value): MA are correctly detected by the output image.
FN (False Negative): MA are falsely detected as nonMA.

EXPECTED RESULTS

Data set of 30 images is tested using the MATLAB technology. Each of the image is taken from the DIARETDB1.Time taken to process each image approximately is 5 minutes. The MA are the red dotsand they are very small in size. The obtained imageswill be compared with ground truth image which areidentified by doctor.

Sensitivity of the image is calculated.

SL NO	Images	OUTPUT Images	Ground truth Images	Sensitivity (%)
		TP	FN	
1	Image 1	3	1	75
2	Image 2	7	5	76.92
3	Image3	7	8	76.92
4	Image4	8	7	63.15
5	Image5	5	4	62.50
6	Image6	5	7	62.50
7	Image7	3	3	66.66
8	Image8	8	10	73.33
9	Image9	4	10	71.42
10	Image10	7	30	63.63
11	Image11	3	10	60.00
12	Image12	10	7	71.42
13	Image13	12	9	80.00
14	Image14	12	18	70.58

15	Image15	7	7	70.00
16	Image16	8	3	72.72
17	Image17	3	4	60.00
18	Image18	13	29	76.47
19	Image19	7	10	71.42
20	Image20	11	9	68.75
21	Image21	16	13	66.66
22	Image22	11	10	73.33
23	Image23	2	6	76.92
24	Image24	10	8	71.42
25	Image25	11	3	78.57
26	Image26	8	2	80.00
27	Image27	1	1	83.33
28	Image37	4	6	66.66
29	Image43	5	6	71.42
30	Image52	5	5	62.50
		Average		70.81

Table 1: Sensitivity calculation of 30 images

IV CONCLUSIONS

In this paper, we detect the red lesions of the fundus images. The process contains seven steps to detect MA's. The proposed method does the red and green channel extraction. The median filter is applied to the image. We then proceed for the vascular tree extraction. In the vascular tree extraction, the thresholding-based method is used. The cluster level set segmentation is performed after extraction of vessels. Once the level set segmentation is implemented, the very next procedure is detect the spots. Final step after detecting spots is to detect MA's. This is later compared with the ground truth image. Total of 30 images were taken. The sensitivity was calculated accordingly and we obtained a sensitivity of 70.81%.

Future enhancement of our work can be done by using the Morphological Robust Approach. Thereby, methodology helps to increase the sensitivity.

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