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Detection of Microaneurysm in Retinal Image

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ABSTRACT
Diabetic retinopathy considered as main cause of blindness. Presence of microaneurysm (MA) is the first symptoms of diabetic retinopathy. This paper presents a method for detection of microaneurysms from retinal image by applying preprocessing method in order to remove blood vessels using morphological operations. This preprocessed image was then used for feature extraction. This algorithm is tested on publically available dataset DIARETDB1.As a result, the weighted error rate (WER) and receiving operating curve (ROC) is given for this method.

General Terms
Detection of microaneurysm, Morphological operation

Keywords
Microaneurysm (MA), Diabetic Retinopathy (DR)

1. INTRODUCTION
Diabetic Retinopathy (DR) is a severe case of eye disease which causes blindness in most of the diabetic patients. This abnormality causes due to change in blood vessels. It is a visual manifestation of diabetes a systemic disease, which affects up 75 percent of patients who have had diabetes for 20 year or more. Treatment for DR are available, it required early diagnosis and continuous monitoring of patients. But it is not possible for the ophthalmologist that continuous monitoring of the large number of patients. Early detection could limit the disease severity and help ophthalmologist in investigating and treating the disease [1]. With the help of early treatment, the risk of blindness can be reduced up to 50%. The remedy is to espouse a mass screening for the patient suffering from diabetes. Manual detection required more time and it is ineffective method for large number of image dataset. Hence automated diagnosis of DR should reduce the severity of disease. The patients affected by diabetic retinopathy may not experience visual loss until the disease has progressed to a severe stage, when the treatment is less effective. Early detection and regular monitoring is required for treating the diabetic retinopathy[11].

Microaneurysms (MAs) are the first symptom of DR which is caused due to weakening of blood vessels. These appear as red, small, round shape dots.If the microaneurysm are ruptured it occur as hemorrhages. Diabetic retinopathy does not have any early warning sign. Non-proliferative diabetic retinopathy (NPDR) is the first stage of DR, the symptoms are not visible to eye. NPDR is detected by fundus photograph, in which MA can be seen. The content of blood vessels leak into the macular region this can occur at any stage of NPDR. The second stage is proliferative diabetic retinopathy (PDR) where the abnormal new bloodvessels are formed; these can burst and bleed which form hemorrhage.

Example of DR is shown in the Figure (1). It shows MAs as exhibiting sign of DR [2].

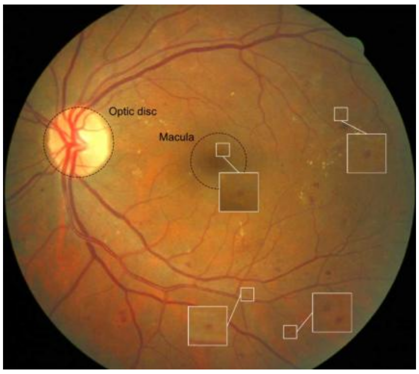


Figure 1: Some MAs are zoomed in image [2].

S. Abdelazeem, [12] proposed a method which applied a recursive region growing procedure for segmentation of both the vessels and red lesions in a fundus image. To detect the vessels a neural network was used. The objects that remain after removal of the detected vasculature are labeled as microaneurysms. A sensitivity and specificity are 77.5% and 88.7% was reported respectively. A.Frame et al.[3], T. Spencer et al. [4], M.J.Cree et al.[5] propose a method like morphological operation to segment MA in fundus image. The computerized approach for segmentation of MA was proposed by Laÿ [7] and Baudoinetet al. [8]. This method calculates linear structuring element with maximum morphological opening. The result of this image is the structures that are smaller than structuring element are removed. Hence to obtain MA top-hat transform used. Alan D Fleming et al. [10] performed preprocessing with candidate region growing, candidate evaluation technique and described how one can improve the capability to differentiate MA and other dots on the retinal image using image contrast normalization , better contrast normalization was obtained by applying the watershed transformed. The local vessel detection technique handled dots within the blood vessels.

2. METHOD
The proposed system used four main steps. The first step is preprocessing which include finding of green channel image. Here green channel is use because retinal image have highest contrast in green channel than red and blue channel. Second step is detection of blood vessels. Third step is removal of high intensity region. And the last step is top-hat transform. Figure (2) Shows steps require for detection of MAs.

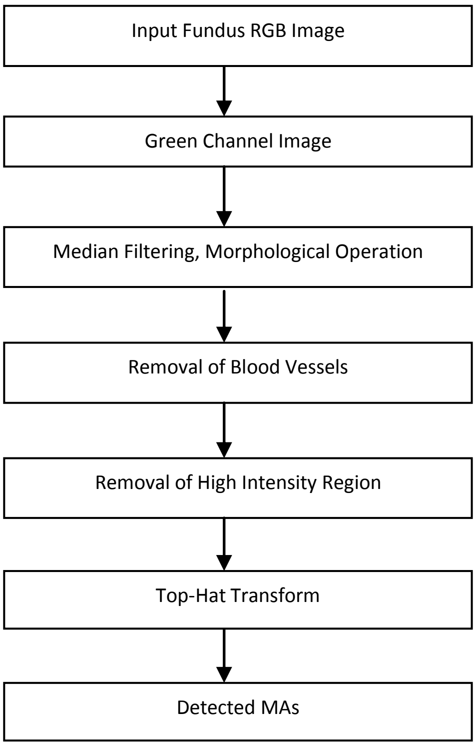
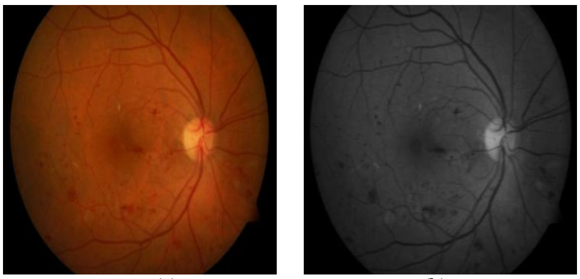


Figure 2: Flow chart for detection of MAs.

2.1 Preprocessing

In fundus image different types of noise are present; to improve the image quality preprocessing step is used. From original RGB color image shown in figure(3a), green plane image (Ig) is used. Retinal image have highest contrast in green channel as blue channel does not contain any information and red channel is saturated. The green channel image is shown in figure (3b).



(a) (b)

Figure 3: Preprocessing step (a) Original Image (b) Green channel image

2.2 Detection of Blood Vessels

In medical image vessel detection plays very important role, it acts as one of the preprocessing step for finding MAs. Vessel detection helps in image reconstruction, segmentation, and data compression. There are different methods of finding vessels such as Laplace of Gaussian, Roberts Operator, Prewitt Operator, Sobel Operator, Canny Edge Detector etc. [6].

To detect MAs which is the presence of very small dots having a diameter of 10 to 100 µm., to gate this it is need to remove unwanted area such as vessels, high intensity regions like exudates, optic disk etc. To remove vessels, image goes through median filtering then morphological operation. Vessels are needed to be removed because vessels and MAs both are reddish in color and MA does not present on vessels.

For vessel detection two intermediate images can be generated on the basis of thin (f_{tn}) and thick line (f_{th}). Morphological open function is use for thinning and thickening of image.

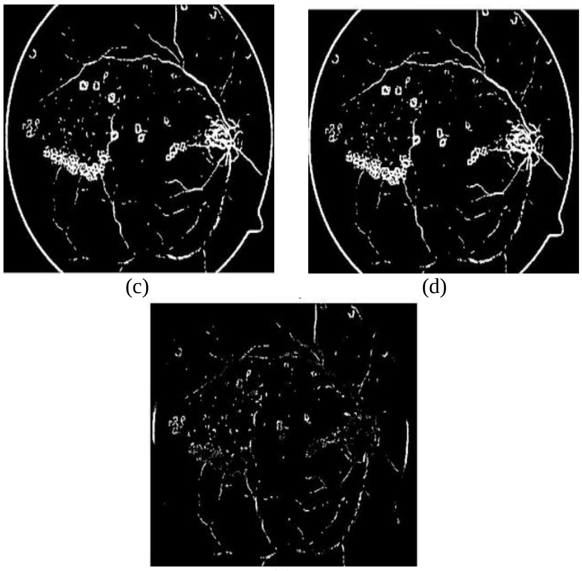
$$A \circ B = (A \ominus B) \oplus B \tag{1}$$

Where, B is the morphological structuring element.

Figure (4c) and (4d) shows the thick and thin line image respectively.

After taking difference of these two images residual image (Res.) is obtained this is shown in figure (4e).

$$R_{es} = f_{tn} - f_{th} \tag{2}$$



(c) (d)

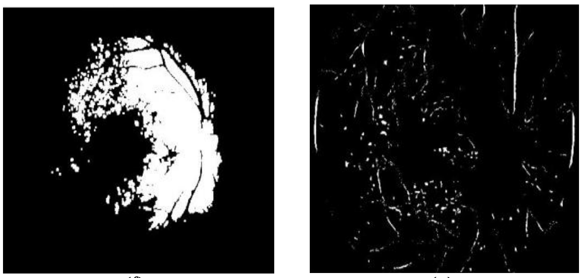
(e)

Figure 4: (c) Thin line image (d) Thick line image (e) Residual image

2.3 Removal of High Intensity Region

Remove bright lesions for detection of MA like exudates because it is possible that it can be wrongly detect as MA. High intensity region is calculated by using dilation on green channel image (Ig) shown in figure (5f). Figure (5g) shows image after removing high intensity region.

$$A \oplus B = \left\{ z (\hat{B})_z \cap A \neq \varnothing \right\} \tag{3}$$



(f) (g)

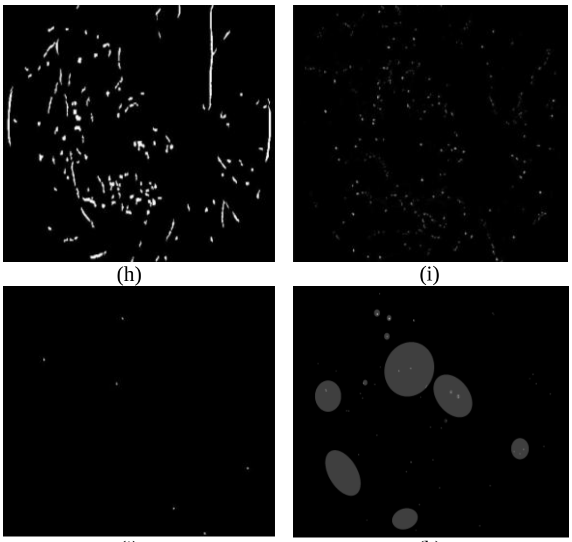
Figure 5: (f) High intensity region (g) Removal of high intensity region.

2.4 Detection of Microaneurysm

Due to weakness of vessel wall MAs are formed. It is a swelling of retinal capillaries appear as red, small dots with the diameter of 10 to 100 µm.

Here, top hat transform is used to find the MAs present in the fundus image. Here original image is subtracted by its area opened image and finally MAs are obtained by applying thresholding on top-hat transformed image. Detected MAs are shown in figure (6j).

$$T_{hat}(f) = f - (f \circ b) \quad (4)$$



(h) (i) (j) (k)

Figure 6: (h) Removal of smaller object less than threshold (i) Top-Hat transformed image (j) Detected MAs (k) Ground truth image

3. RESULTS

The proposed algorithm applied on data set DIARETDB1 consist of 89 images. Among the all images, 84 images shows some sign of MAs. The ground truth is also available with the dataset for each image (for example as shown in the figure 6(k)). The various markings made on the ground truth by different expert at various confidence levels. The result of this algorithm is compared with the ground truth image present in the data set (example of ground truth available in dataset is shown in figure 6(k)).

Receiving operating curve (ROC) shows the graphical representation for sensitivity (SN) that is true positive rate (TPR) and 1- specificity (SP) that is false positive rate (FPR) the curve is shown in figure(7).

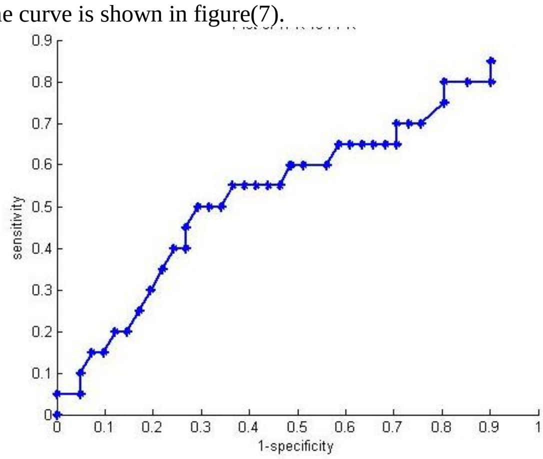


Figure 7: ROC Curve

To find the weight error rate (WER) two measures are combining such as sensitivity and specificity [13].

$$WER(R) = \frac{FPR + R(FNR)}{1+R} = \frac{1 - SP + R*(1 - SN)}{1+R} \quad (5)$$

Where, $R = \frac{C_{FNR}}{C_{FPR}}$ is the cost ratio between FPR and FNR. In the DIARETDB1 the following measures are computed: WER (0.1) (FNR is an order of magnitude less harmful), WER (1) (FPR and FNR are equally harmful) and WER (10) (FNR is an order of magnitude more harmful). These measures are computed from the nearest true points on the equally harmful) and WER (10) (FNR is an order of magnitude more harmful). These measures are computed from the nearest true points on the ROC without interpolation. Following table shows the value of WER for proposed method and DBRERDB1 dataset. Table (1) shows evaluated result by proposed method and table (2) shows result given with dataset [13]. Table gives value of FPR, FNR, and WER for R=0.1, 1 and 10.In data set for R=1 the value of FPR is 0.4634. With the help of proposed algorithm the value of FPR for R=1 is 0.2683 which is less than the value given in data set.

Table 1. RESULT OBTAINED BY TOP-HAT TRANSFORMED METHOD.

	FPR	FNR	WER	
Microaneurysm	0.9024	0.1500	0.2184	R=0.1
	0.2683	0.5000	0.3841	R=1
	0	0.9500	0.0864	R=10

Table 2. RESULT GIVEN WITH DIARETDB1 DATASET

	FPR	FNR	WER	
Microaneurysm	0.4634	0.1500	0.1785	R=0.1
	0.4634	0.1500	0.3067	R=1
	0	0.8000	0.0727	R=10

4. CONCLUSION AND FUTURE SCOPE

This paper mainly present a method for detection of microaneurysms on retinal image, based on TOP-HAT transformed method. It is an efficient method for detection of microaneurysm. The algorithm is applied on different quality of images. The main aim of this algorithm is to detect the microaneurysms not the number of microaneurysms present. Since manually detection of diabetic retinopathy features such as small microaneurysms is very difficult, the proposed algorithm can help to the ophthalmologists for mass screening of patients at great extent.

The proposed algorithm mainly works on an aspect of identification of microaneurysm in fundus photographs. Further pre-processing and post-processing techniques may be used on proposed algorithm. Such techniques will contribute to detect the number of microaneurysm present in retinal image, hence improvement in algorithm results in more robust and precise detection that eventually can be accepted for clinical purposes.

5. ACKNOWLEDGMENTS

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