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# Enhancement of Blood Vessel for Microaneurysm Detection and Diabetic Retinopathy using an Ensemble Based System

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***Abstract:*** **Diabetic retinopathy is damage to the retina (retinopathy), specifically blood vessels in the retina, caused by complications of diabetes mellitus. Diabetic retinopathy can eventually lead to blindness if left untreated. Approximately 80% of all patients who have had diabetes for at least ten years suffer from some degree of diabetic retinopathy. The retina is the light-sensitive membrane that covers the back of the eye. If diagnosed and treated early blindness is usually preventable. Diabetic retinopathy generally starts without any noticeable change in vision. However, an eye doctor (ophthalmologist) can detect the signs. This research proposes a method for accurate vessel segmentation and microaneurysm (MA) detection in retinal images in its early stage. Colored retinal images used in this work are obtained from publicly available DRIVE and STARE database.**

***Keywords:*** **Diabetic Retinopathy (DR) , Microaneurysms (MAs).**

## I. INTRODUCTION

DR is a common cause of blindness especially in developed countries. However, at an early stage an appropriate treatment may slow down the progression of this disease. Thus, mass screening of patients suffering from diabetes is highly desired, but using manual grading which is slow and resource demanding. Therefore, much effort has been made to establish reliable computer aided screening system based on digital color fundus images [1]. The promising results reported by Fleming *et al* [2], and Jelinek *et al* [3] indicate that automatic DR screening systems are getting closer to be used in clinical settings.

A key feature to recognize DR is to detect MA in the fundus of the eye. The importance of handling MAs are two fold. First, they are normally the earliest signs of DR, hence their timely and precise detection is essential. On the other hand, the grading performance of computer-aided DR screening systems highly depends on MA detection [3], [4].

One way to ensure high reliability and raise accuracy in a detector is to consider ensemble-based systems, which have been proven to be efficient in several fields. In MA detection, detectors provide spatial co-ordinates as centers of potential MA candidates.

Figure.1 Sample digital fundus image with MA

To increase the accuracy of ensembles, we must identify the weak points of MA detection. The first difficulty originates from the shape characteristics of MAs. They appear small circular dark spots on the surface of the retina (as shown in fig.1), which can be hard to distinguish from fragments of the vascular system or from certain eye features. Most MA detectors tackle this problem in the following way: first, the green channel of the fundus image is extracted and preprocessed to enhance MA like characteristics. Then, in a coarse level step (which will be referred as candidate extraction), all MA-like objects are detected in the image. Finally a fine level algorithm (usually a supervised classifier) removes the potentially false detection based on some assumptions about MAs.

## II. RELATED WORK

Balint Antal [5] have proposed reliable microaneurysm detection in digital fundus images used in medical image processing. They propose an ensemble-based framework to improve microaneurysm detection. Unlike the well known approach of considering the output of multiple classifiers, they propose a combination of internal components of microaneurysm detectors, namely preprocessing methods and candidate extractors. They have evaluated their approach for microaneurysm detection in an online competition, where his algorithm is currently ranked as first, and also on two other databases. Since, microaneurysm detection is decisive in diabetic retinopathy (DR) grading, they also tested the proposed method for this task on the publicly available

Messidor database, where a promising AUC 0.09 (=, -) 0.01 is achieved in a "DR/non DR" – type based on the presence or absence of the microaneurysms.

The grading results presented in this paper are already promising. However, a proper screening system should contain other components, which is expected to increase the performance of this approach, as well.

M.Usman Akram [6] Retinopathy is a progressive disease and is broadly classify into two Non proliferative diabetic retinopathy (NPDR) and proliferative diabetic retinopathy (PDR). A sign of PDR is the appearance of new blood vessels in the fundus area and inside optic disc known as neovascularization. The study of blood vessel is very important for detection of neovascularization. In this paper, they present a method for vessel detection which can be used for detection of neovascularization. The paper presents a new method for vessel segmentation using a multilayered thresholding technique. The method is tested using two publicly available retinal image databases and an experimental result shows the significance of proposed work. Fig, 2 shows the complete flow diagram of proposed work [6].

Accurate and timely detection of vascular abnormalities can help in prevention of vision loss cause due to diabetic retinopathy. Using the method [6] for accurate vessel segmentation which can be used for detection of neovascularization. The blood vessels are enhanced using two dimensional wavelets and a new multilayered thresholding technique is used for vessel segmentation. Abnormal blood vessels are detected using a sliding window technique.

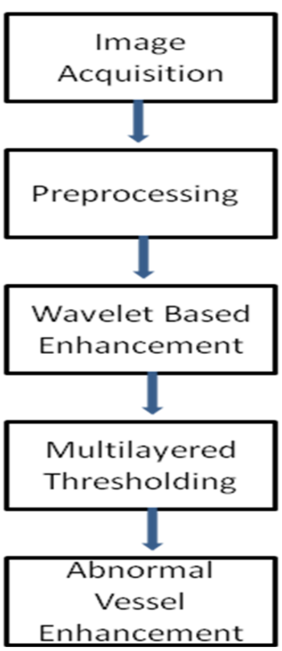



Figure 2: Flow diagram of proposed work [6]

Diego Marin [7] presents a new supervised method for blood vessel detection in digital retinal images. He uses a neural network (NN) scheme for pixel classification and computes a 7-D vector composed of gray-level and moment invariants-based features for pixel representation. He evaluated it on the publicly available DRIVE and STARE databases, widely used for this purpose, since they contain retinal images where the vascular structure has been precisely marked by experts. Method performance on both sets of test images is better than other existing solutions in literature. The method proves especially accurate for vessel detection in STARE images. Its application to this database (even when the NN was trained on the DRIVE database) outperforms all analyzed segmentation approaches. Its effectiveness and robustness with different image conditions, together with its simplicity and fast implementation, make this blood vessel segmentation proposal suitable for retinal image computer analyses such as automated screening for early diabetic retinopathy detection.

## III. PROPOSED WORK

In this paper, we propose an effective MA detector based on the combination of preprocessing methods and candidate extractors. We provide an ensemble creation framework to select the best combination. Fig. 3 shows the proposed plan of work and methodology.

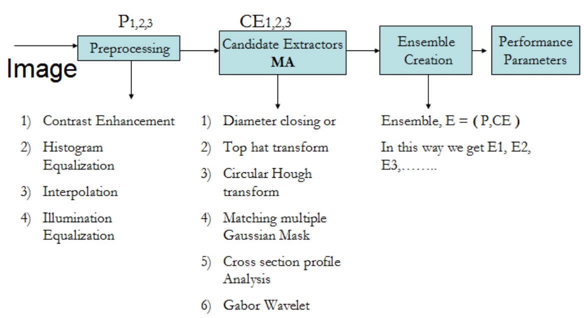



Figure. 3 Proposed plan of work and design methodology

The various steps involved Preprocessing, Candidate Extractors, and Ensemble Creation.

### *A. PREPROCESSING (P)*

In this we present the selected preprocessing methods, which we consider to be applied before executing MA candidate extraction. The selection of the preprocessing method and the candidate extractor components for this framework is a challenging task. Preprocessing method need to be highly interchangeable, we must select algorithms that can be used before any candidate extractor and do not change the characteristics of the original images. Thus we have to select the method which are well known in medical image processing and preserve image characteristics. Color fundus often show important lighting variations, poor contrast and noise. In order to reduce these imperfections and generate images more suitable for extracting the pixel features demanded in the classification step, a preprocessing comprising the following steps is applied –

1. Vessel central light reflux removal,
2. Background homogenization,
3. Vessel enhancement.

***1. Vessel Central Light Reflux Removal***

The retinal blood vessel have lower reflectance when compared to other retinal surfaces, they appear darker than the background. The cross-sectional grey-level profile of vessel can be approximated by a Gaussian shaped curve (inner vessel pixels are darker than the outermost ones), some blood vessels include a light streak (known as a light reflex) which runs down the central length of the blood vessel. To remove this bright strip, the green plane of the image is filtered by applying a morphological opening using a three-pixel diameter disc, defined in a square grid by using eight-connectivity, as a structuring element. Disc diameter was fixed to the possible minimum value to reduce the risk of merging close vessel. Igamma denotes the resultant image for future references.

***2. Background Homogenization***

Fundus image often contains background intensity variation due to nonuniform illumination. Consequently, background pixels may have different intensity for the same image and although their grey-levels are usually higher than those of vessel pixels (in relation to green channel images), the intensity values of some background pixels is comparable to that of brighter vessel pixels. So with the purpose of removing these background lightening variations, a shade-corrected image is accomplished from a background estimate. This image is the result of a filtering operation with a large arithmetic mean kernel, as described below –

1. Firstly, a 3×3 mean filter is applied to smooth occasionally salt and pepper noise. Further noise smoothing is performed by convolving the resultant image with a Gaussian kernel of dimensions m×m = 9×9, mean μ = 0 and variance σ^2 = 1.8^2.

2. Secondly, a background image *IB*, is produced by applying a 69×69 mean filter. When this is applied to pixels in the FOV near the border, the results are strongly biased by the external dark region. To overcome this problem, out of the FOV grey-levels are replaced by average grey-levels in the remaining pixels in the square. Then the difference between Igamma and IB is calculated for every pixel.
D(x, y) = Igamma – IB(x, y)

3. Finally, a shade-corrected image Isc is obtained by transforming linearly RD values into integers covering the whole range of possible grey-levels ([0-255], referred to 8-bit images). The shade-correction algorithm is used to reduce background intensity variations and enhance contrast in relation to the original green channel image.

4. Besides the background intensity variations in images, intensities can reveal significant variations between images due to different illumination conditions in the acquisition process. In order to reduce this influence, a homogenized image IH is produced as follows- The Histogram of Isc is displaced toward the middle of the grey scale by modify pixel intensities according to the following grey level global transformation function –

$$g_{output} = \begin{cases} 0, if\ g < 0 \\ 255, if\ g > 255 \\ g, oherwise \end{cases}$$

where $g = g_{Input} + 128 - g_{Input\_max}$

Thus, background pixels in images with different illumination conditions will standardize their intensity around this value.

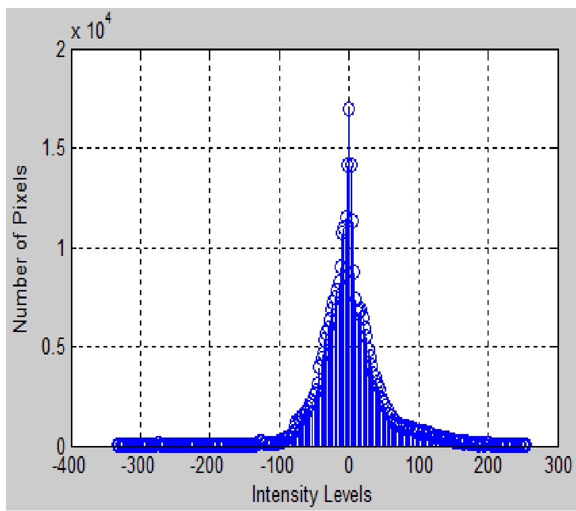


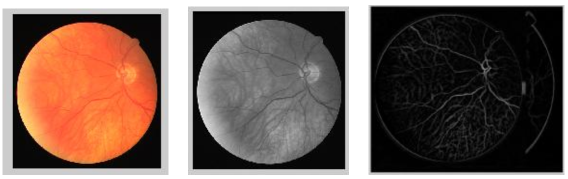

Figure 4 Histogram of Isc

***3.Vessel Enhancement***

The final preprocessing step consists of generating a new vessel enhanced image Ive. Vessel enhancement is performed by estimating the complementary image of the homogenized image IH, and applying the morphological Top-Hat transformation

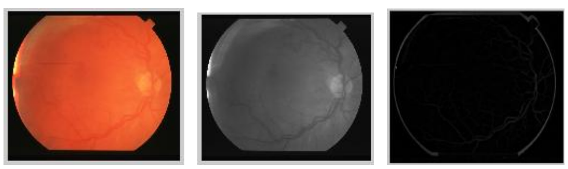
$$I_{VE} = I_H^C - \gamma(I_{HVE}^C)$$

where γ is a morphological opening operation using a disc of eight pixels in radius. Thus, bright retinal structures are removed (i.e. optic disc, possible presence of exudates or reflection artifacts), the darker structures remaining after the opening operation become enhanced (i.e. blood vessels, fovea, and possible presence of MA).



(a) (b) (c)

Figure 5 Application of preprocessing on image of DRIVE database. (a) Original image, (b) Green channel of original image, (c) Vessel enhanced image.



(a) (b) (c)

Figure. 6 Application of preprocessing on image of STARE database. (a) Original image, (b) Green channel of original image, (c) Vessel enhanced image.

### *B. CANDIDATE EXTRACTION (CE)*

Candidate extraction is a process that aims to spot any objects in the image showing **MA-**like characteristics.
Individual **MA** detectors consider different principles to extract MA candidates.
By using different methods for candidate extractors which can preserve the characteristics of retinal image, candidate extraction can be done.

### *C. ENSEMBLE CREATION (E)*

One way to ensure *high reliability* and raise *accuracy* in a detector is to consider ensemble-based system.
Ensemble, E = **(P, CE**)
In this way we get E1, E2, E3,….

## IV. EXPERIMENTAL RESULTS

For clinical feature analysis, blood vessel enhancement is essential for deep layer features. For feature extraction various image enhancement methods are used. Figure 5, 6 shows vessel enhanced images of DRIVE and STARE image obtained from preprocessing. In preprocessing stage, preprocessing operation of images is done and various features are extracted to detect microaneurysm.

## V. CONCLUSION AND FUTURE SCOPE

This paper presents a comprehensive method for preprocessing of retinal image to obtain enhanced blood vessels for detection of microaneurysm. For improvement in results obtained there are number of areas which needs further investigation i.e the system can be improved in the future with adding new methods for Candidate extraction and Ensemble Creation.

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