

Modified Morphology and K-NN Classifier Based Microaneurysms Detection in Retinal Fundus Images

¹Ravindra Badgujar, ²P J Deore

¹Research Scholar, ²Prof. & Head

^{1,2} Department of E&TC

^{1,2} R C Patel Institute of Technology, Shirpur, MS, India

Abstract

Microaneurysms are primary lesions of non-proliferative diabetic retinopathy, which is one of the diabetic complications. Diabetic retinopathy is asymptomatic disease and must be identified and proper treatment must be given at primary level. If DR is not diagnosed at primary level, it grows and develops more hazardous lesions like hemorrhages and exudates and lowers the vision and may leads to complete blindness. Hence a new method of MA detection is proposed in this paper which uses morphological operations and k-NN classifier to identify the MA. It also gives grading of DR depending on count of MAs.

Index Terms– Microaneurysms detection, Diabetic Retinopathy grading, k-NN classifier, vessel vasculature.

INTRODUCTION

Diabetes is rapidly increasing in world, which arises due to obesity, lazy lifestyle, improper diet and hereditary. In diabetes body is not able to generate required amount of insulin or not utilized generated insulin properly. [1]. Due diabetes over long time, enough insulin is not produces or utilized and excess sugar is available in blood in the form of glucose. [2]. Excess sugar may affect to human body, are commonly referred to as diabetic complications. Diabetes contributes to heart attacks, cardiovascular disease, strokes, kidney diseases and diabetic retinopathy [3].

People with diabetes over a decade are more prone to have an eye disease called diabetic retinopathy. The high blood sugar levels cause damage to blood vessels in the retina affect the visual system. These affected blood vessels can swell, leak or blocked, and impede blood circulation to eye and retinal muscles grow new blood vessels on the retina and weaken your vision [4].

Stages of diabetic eye disease

There are two main stages of diabetic eye disease [4].

Non-Proliferative Diabetic Retinopathy (NPDR)

This is the early stage of diabetic eye disease and many people with diabetes have it. NPDR can further classified in three subcategories called mild NPDR, moderate NPDR and severe NPDR. In mild NPDR, tiny blood vessels leak, making the retina swell and dark circular spot are generated in retina, known as microaneurysms. In moderate NPDR, blood circulation is blocked and the macula swells, it is called macular edema. In severe NPDR, the new abnormal blood vessels are started to grow. This is the most common reason why people with diabetes lose their vision.

Also with NPDR, blood vessels in the retina can close off. This is called macular ischemia. When that happens, blood cannot reach the macula. Sometimes tiny particles called exudates can form in the retina. These can affect your vision too.

Proliferative Diabetic Retinopathy (PDR)

PDR is the more advanced stage of diabetic eye disease. It happens when the retina starts growing new blood vessels. This is called neovascularization. These fragile new vessels often bleed into the vitreous. If they only bleed a little, you might see a few dark floaters. If they bleed a lot, it might block all vision. These new blood vessels can form scar tissue. Scar tissue can cause problems with the macula or lead to a detached retina. PDR is very serious, and can steal both your central and peripheral (side) vision.

In NPDR, different signs or lesions of retinopathy can exist, such as microaneurysms (MAs), haemorrhages (HMs), exudates (EXs), and inter-retinal microvascular abnormalities [5]. These DR lesions are developed in human eye and are accessed by ophthalmologist using various modern tools. Traditionally the DR assessment is carried out using direct ophthalmoscopy or slit lamp biomicroscopy. Now, digital fundus photography is used for DR assessment due to its more sensitiveness as compared to direct ophthalmoscopy and is comparable to slit lamp examination.

A digital fundus camera has the following advantages [6]:

- Fast and convenient imaging of the retina.
- Storage, archiving, and transmission capabilities.
- Use of the images for quality assurance.
- Ability to enhance images.

Ophthalmologists are assessing the fundus retinal images and grades the DR. Now in modern era, image processing techniques are employed to process the retinal fundus images and detect DR and further grading in different classes. The use of image processing techniques eliminates the need/availability of eye expert (ophthalmologist), human errors incorporated during assessment and reduces the time of assessment.

To prevent partial or full vision loss due to diabetes, lesions developed during earlier stages of DR must be detected and identified and patient must follow scheduled screening and proper treatment. The NPDR is initial stage of DR and MAs are the primary DR lesions developed in retina. To prevent vision loss due to DR, MAs must be detected from fundus images and depending on extent of MAs, DR can be graded. The processing steps involved in MA detection are shown in figure 1.

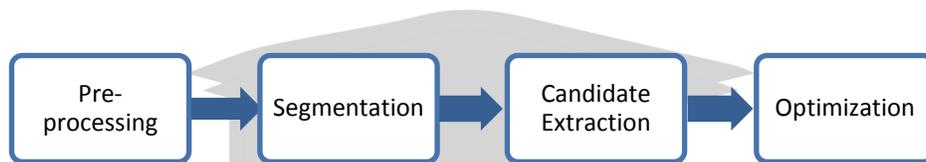


Figure 1: The processing step for MA detection

LITERATURE REVIEW

Several image processing based approaches have been proposed for MA detection. Most of the proposed approaches use preprocessing to remove noise, segmentation to remove various anatomical structures, candidate extraction to detect required lesion and finally classification of MA candidate is carried out based on computed features.

Luca Giancardo et al introduced New Radon Cliff operator for MA detection. Their three-step proposed algorithm is uses candidate's selection in first step, detection of microaneurysms in second step and third step provides probability evaluation using new Radon Cliff. Using proposed algorithm, single noisy circular structures are detected regardless of of their strength and size [7]. Modified morphological operators based MA detection is proposed by AkaraSopharak et al [8] to investigate microaneurysm detection in low-contrast and non-dilated pupil retinal images. Morphological approach following blood vessel elimination is proposed by Rukmini Roy et al [9]. After fractal analysis of vessel vasculature, MAs are examined for distinctive using edge detection and reconstruction approach. K. Adal et al [10] proposed Robust Blob Descriptors based approach for automatic detection of MAs. They used robust pattern recognition, MA descriptors followed by classifier. SURF and Radon Transform features, these MA descriptors are used for MA detection. NiladriSekharDatta et al proposed location based contrast enhancement process, known CLAHE for the detection of retinal changes in DR images which helps in dynamic preservation of the local contrast characteristics of an image [11].

Shan Ding and Wenyi Ma proposed dynamic multi-parameter template (DMPT) matching system for accurate MA detection [12]. Initially proposed algorithm is applied to enhanced image for template matching and separating the possible MAs. AWS algorithm for the MAs detection is utilized in feature extraction. Ivo Soares et al [13] proposed a Novel Neighborhood Analysis and scale-space method based MA detection. Initially, segmentation of the blood vessel and MA candidates is done at coarse level then followed at fine level to analyze MA candidates. Then set of Gaussian-shaped matched filtering approaches is used to identify false MA and new neighborhood analysis method is employed to label true MA. Wei Zhou et al proposed, sparse PCA based classification method for MA detection. They used unsupervised classification method based on Sparse PCA to find the latent structure of MAs [14]. K-Nearest Neighbor classifier is exploited by Su Wang et al to detect MA [15]. Candidate objects are identified using dark object filtering then their cross section profiles are analyzed using singular spectrum. Scale factor is measured and used further to increase difference in true and false MA candidates. Finally statistical features of profiles are used as input for K-Nearest Neighbor classifier. The numbers of MAs detected are used for bi-level classification of retinal images. The classes are with DR and without DR.

METHOD

The proposed method for MA detection is consisting of four steps as shown in figure 2. Various datasets of fundus retinal images are available online for testing and validation of proposed DR detection approaches. These available retinal fundus images are used as input

to our proposed system. The available fundus images are noisy and have low contrast. Preprocessing is used to eliminate the noise and enhance image quality, utilizing Gaussian filtering and histogram equalization. The anatomical structures are identified in segmentation stage using adaptive thresholding and morphological operation. The optical disc and vessel vasculature are eliminated in segmentation. The MA candidates are extracted in third step using geometrical features of MA and finally they are classified in last step.

The Gaussian filter is a non-uniform low pass filter. Gaussian filtering is used to blur images or adding average effect and remove noise. The degree of blur or averaging is depends on standard deviation parameter of Gaussian filter. Histogram equalization is a technique for adjusting image intensities to enhance contrast. Retinal fundus images are low contrast images hence must be histogram equalized before segmentation.

In segmentation we need to identify and eliminates anatomical structure of eye like optic disc (OD) and vessel vasculature to avoid false MA detection. The OD is largest bright area in retinal image. It is identified by morphological operations by finding largest area blob in image and finally eliminating it. The vessel vasculature is network of blood vessels in retinal images. It is identified using canny edge detection followed by dilation and erosion.

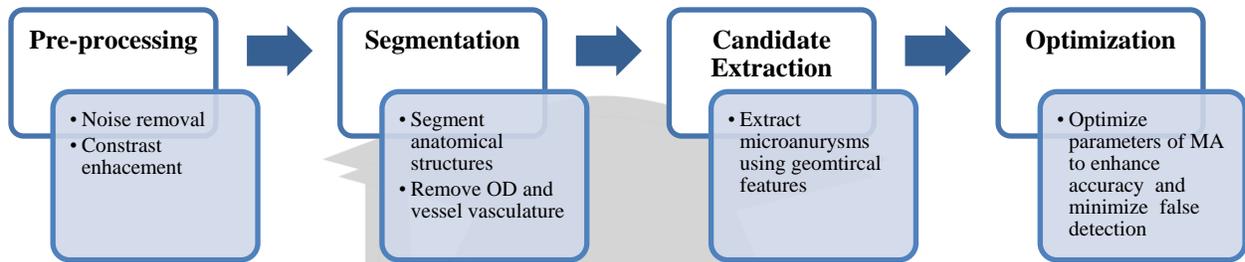
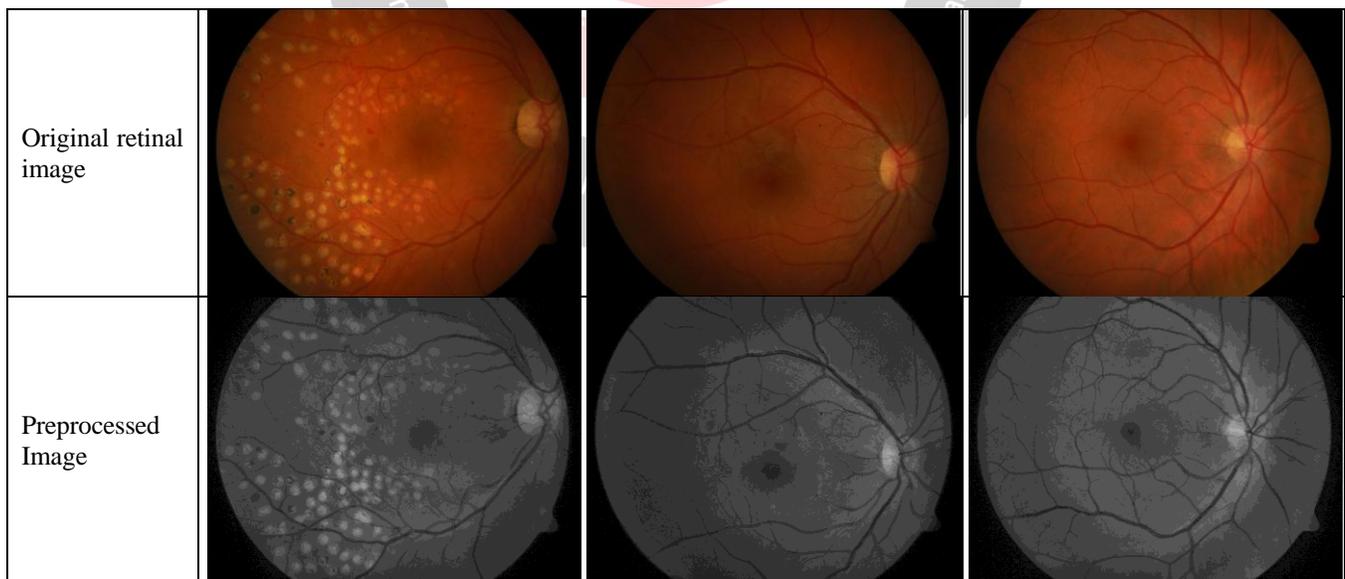


Figure 2: The flow of proposed method

After eliminating OD and vessel vasculature, the processed image is used to find various blobs. The blobs are then analyzed using various geometrical features like area, perimeter, major axes length, minor axis length, solidity and eccentricity. The MAs are small dark disc like spots. Hence using standard dimensions of MAs, we define the thresholding of various geometrical features using KNN classifier.

RESULTS AND DISCUSSION

The proposed MA detection algorithm is developed using MATLAB R2013a and uses the retinal images from online dataset DIARETDB0. The figure 3 shows simulated results of proposed MA detection approach at various stages.



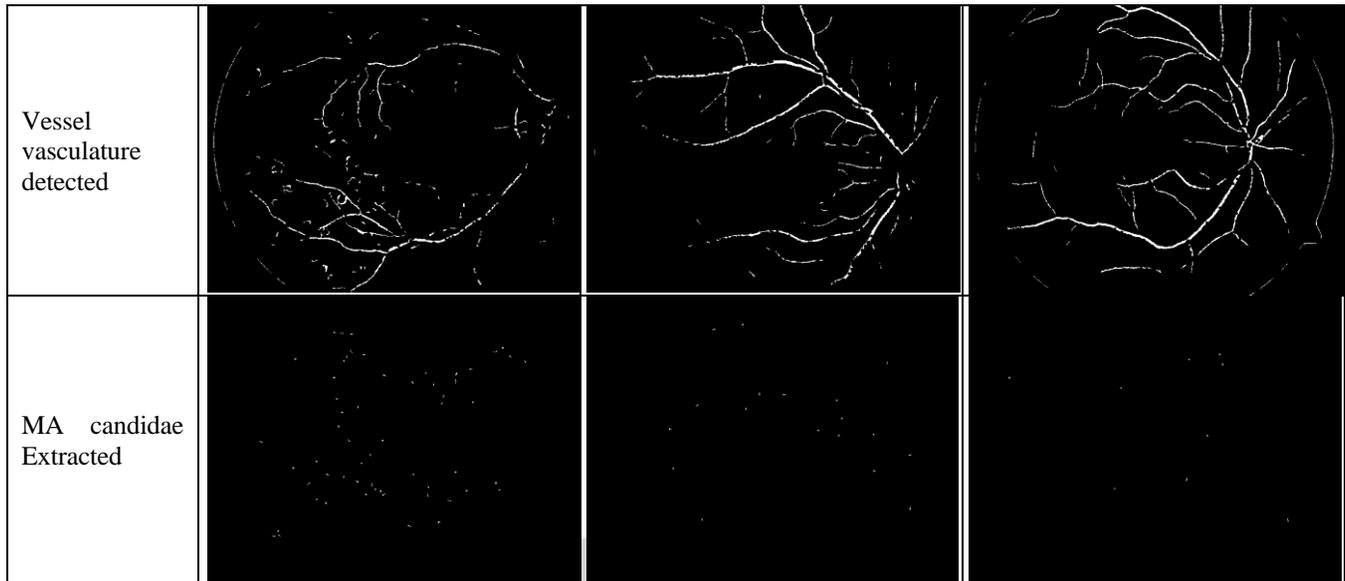


Figure 3: Simulated results of proposed MA detection approach

MA detected using proposed algorithms are shown in figure 3. The detected MAs are represented as white areas on black background. For training phase 20 images are used while 40 images are tested. Table 1 represents the statistical measure of the proposed system for DIARETDB0 dataset at image level.

Table I. Statistical measure of the proposed system

Measure	True Positive (TP)	True Negative (TN)	False Positive (FP)	False Negative (FN)
Dataset (40)	24	10	7	3
Performance Parameters (%)	Sensitivity	Specificity	Accuracy	Precision
	77.42	76.92	85.00	77.42

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