A Review Paper On Detection And Extraction Of Blood Vessels, Microaneurysms And Exudates From Fundus Images

Soju George, Bhailal Limbasiya

Abstract: Diabetic Retinopathy (DR) is a medical condition which affects the normal vision of a human. Patients having long history of diabetes tend to be affected by DR. An increased level of blood sugar may lead to an eye disease termed as DR. Early detection of DR helps the ophthalmologists to advise proper treatment to save the vision of the patient. In this paper, a survey has been carried out and different techniques are discussed to extract different features. Exudates, Microaneurysms and abnormal growth of blood vessels are some of the symptoms of DR. Preprocessing of an image is always required to obtain a contrast enhanced image. The paper provides overview of some of the preprocessing techniques used till now and different methods to extract exudates, microaneurysms and blood vessels are discussed.

Index Terms: Blood vessels, BPDFHE, CLAHE, Diabetic retinopathy, Exudates, Fundus, Microaneurysms.

1 Introduction

In the modern era, there are lots of diseases that affect the normal life of a human. One such disease is Diabetes, which occur due to the fluctuating insulin levels in a human body. Diabetes tends to affect multiple organs of the body like kidney, eyes, liver, heart etc. When diabetes affects human eyes, the disease is termed as diabetic retinopathy (DR). The blood vessels in a human are very small in size and hence more susceptible. The corrosion of blood vessels starts occurring when the blood sugar levels are increased much above the normal levels for a prolonged period of time. This pathological condition is referred to as DR [2]. In DR, the normal vision of a human is hindered and as time passes by, the vision tends to become weaker. Exudates, micro aneurysms and abnormalities in blood vessels are some features extracted to classify DR. The retina of a human eye gets damaged when proteins and lipids start leaking from the blood vessels causing exudates. Microaneurysms are small areas of balloon like swelling in the retinas tiny blood vessels [1]. DR can also be detected from abnormality in the structure or extra growth of blood vessels. Early detection of these features helps the ophthalmologist to detect the DR and also help in preventing blindness. Detection of these features is done from fundus images. The fundus images are taken from a special type of camera called fundus cameras. The detection of the mentioned features from the fundus images helps the ophthalmologists to decide on the severity of the DR and advise the required treatment to the patients. The paper is organized as follows: Section 2 gives a review of some of the preprocessing techniques used in the literature. In Section 3, various methods for detection and extraction of blood vessels, exudates and microaneurysm are discussed and Section 4 concludes the paper.

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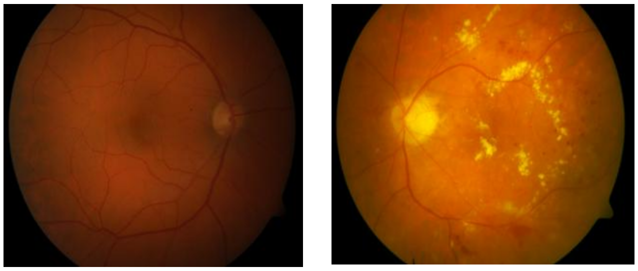


(a) (b)

Figure 1 Fundus image showing (a) Normal image (b) Diabetic Retinopathy image [10]

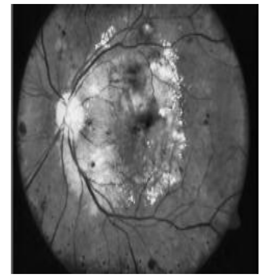
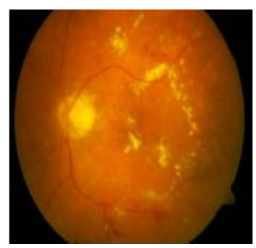
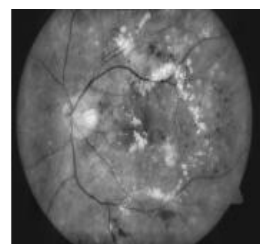
2 Various pre-processing techniques

Preprocessing of an image is always required to extract the features in a more clear and proper manner. Hence lots of research has been carried out to attain better enhanced images. In 2012, Rupsa et.al [2] suggested a preprocessing technique comprising of four steps: Image enhancement, Brightness preserving dynamic fuzzy histogram equalization (BPDFHE), Contrast limited adaptive histogram equalization (CLAHE) and De-correlation stretching. Initially the RGB input image was converted into equivalent grayscale image. In BPDFHE, few functional steps are carried out to convert the low contrast image into a contrast enhanced image. Then CLAHE technique is operated on small regions of the image and any noise present in the image was avoided by amplification. Finally de-correlation technique was implemented for better enhancement of the image. It stretched the intensity and contrast difference present in the areas of the image. In 2012, Marwan et.al [3] carried out four different steps for preprocessing: RGB to gray conversion, contrast enhancement, background removal and filtration. In contrast enhancement step, both morphological top-hat and bottom-hat transforms is used. A combination of both top-hat and bottom-hat transforms is used for giving prominence to the blood vessels with minimum effect on the background intensity levels. Later in background removal stage, the background is removed by subtracting the contrast enhanced image f from the median filtered image fmed. Finally for filtration, Wiener filter or minimum mean square error filter is used to reduce noise in the resulting image. In 2013, Mahendran et.al [11] performed preprocessing to extract the features of exudates from the fundus images. Initially the color image is converted into gray scale and then adaptive median filter is used to remove the noises present in the image. Filtering is performed for the smoothing of the image and for removal of various distortions in the image. And finally, histogram equalization is performed on the filtered image for contrast enhancement. In 2013, M.Tamilarasi et.al [12] performed preprocessing for better visualization of objects with low resolution. After converting the RGB image to gray scale image, histogram equalization is used for enhancement of the image. Then image smoothing technique is carried out for suppression of noise in the image. A non linear smoothing method called median filtering is used for edge preservation. In this technique, the pixel value is replaced by the median of its neighborhood region. In 2013, Yamuna et.al [4] enhanced the image by dividing the preprocessing step in two stages: Illumination equalization and CLAHE. Normally higher contrast is achieved at the centre of the retinal images when compared with the subsequent edges. The reduction in contrast is due to the decreased brightness over the edges. This effect is termed as "Vignetting". To overcome this effect the author has made use of illumination equalization technique. Later to remove the presence of noise in the image, a known technique called CLAHE was used.

3 Various techniques for detection and extraction of blood vessels, exudates and microaneurysms

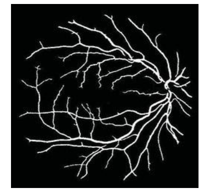
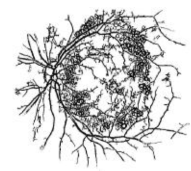
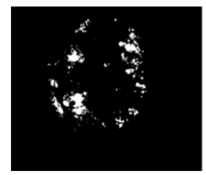
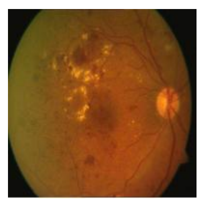
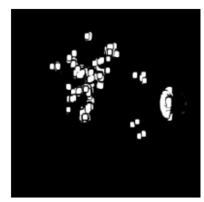
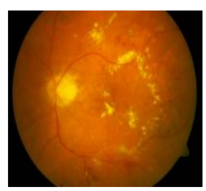
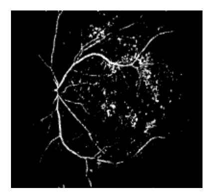
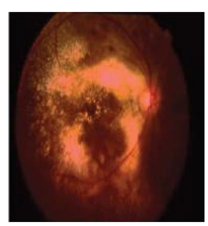
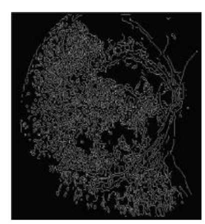
In 2012, Marwan et.al [3], presented an easier approach to detect and extract the blood vessels. The algorithm was carried out in four different stages: Pre-processing, H-maxima transformation, Binarisation & post filtration and multilevel thresholding. In H-maxima transformation, the image is processed to reduce the number of the intensity levels which can be useful for further stages. Multilevel thresholding is an important technique which converts the gray scale image into indexed image by reducing the number of intensity levels so that a threshold value can be easily obtained. . Here pixels of an intensity image are divided into N groups. Finally in Binarisation and post filtration, each pixel has been assigned a value 1 for blood vessel or 0 for background. Some post processing technique was also used to enhance the image.

TABLE I. Results for various preprocessing techniques

Ref. paper	Normal image	Preprocessed image
[2]		
[3]		
[4]		

In 2012, Rupsa et.al [2] suggested an algorithm which consisted of three basic blocks: Matched filtering, local entropy thresholding and length filtering. The retinal fundus images normally have a poor contrast hence detection of blood vessels is tougher. So to enhance the vessels, matched filtering is used. Segmentation of vessels is carried out by local entropy thresholding. Here the spatial structure information is preserved in a proper manner. Post processing is always required as some pixels might be misclassified as vessel parts. Hence length filter is used where connected component labeling technique is used to remove such errors in classification. In 2012, Paintamilselvi et.al [5] carried out blood vessels extraction in five steps. First the RGB image was converted into gray scale. Secondly morphological opening and closing operation is used to reduce small noise. In the third step to obtain the vessel structure a unique technique called top hat transformation was used. In the fourth step, the resultant image was obtained after binarisation and thresholding. Finally connected component analysis was used to obtain an image which was free from noise. In 2013, Anitha et.al [6], proposed a method in which noise is reduced by using a median filter to reduce irregular or smoothing the edges. The hue saturation value of filtered image is obtained. The color retinal images thus obtained were segmented using fuzzy c-means clustering which classifies the segmented regions into exudates and non exudates. The location of exudates with respect to macula is an indication of severity of disease. The advantage of using this proposed method is accuracy of detection of exudates. In 2012, Rupsa et.al [2], proposed a method of automated detection of exudates and retinal features. The optic disc is the brightest region of the fundus image and exudates are bright yellowish regions having lesser area and size than optic disc. In this paper, optic disc is detected using bit plane slicing. However, because of similar intensities of OD and exudates, the latter one is detected by connected component labeling followed by highest area being labeled as OD. Optic Disc is then removed from the image and thus exudates are extracted. Various statistical features of the exudates are defined and based on the values, grading of fundus image is done. In 2009, Ravishankar et.al [7], proposed a robust and computationally efficient approach for the localization of the different features and lesions in a fundus retinal image. Conventional edge detection methods like canny and sobel cannot be used for exudates edge detection because they add noise and miss out key edges. Hence, morphological operators are applied on green channel preprocessed image. Subtraction of the results across the 2 scales gives the boundaries of the exudates. The image P is thresholded in intensity based on training to obtain the binary boundaries. Morphological filling operation is used to obtain a closed contour. A linear classifier is thereafter used for brightness and edge properties of exudates. The exudates patches are localized by thresholding the mean intensities in green channel obtained by training which are greater than a fraction of maximum intensity in channel. Patches satisfying these conditions are considered to be exudates regions. To detect the early stages of Diabetic retinopathy, it has been important to identify the presence of MA. Normally MA appears near the vessels and hence it is hard to distinguish it from the parts of vessels. In 2013, Silvia et.al [8] proposed a method to detect the presence of microaneurysms (MA) in the fundus images. In this paper, MA is detected using Circular Hough Transform. Initially Morphological operations are used to detect the edges. After the detection of edges, Circular Hough transform is applied to the image.

TABLE II. Results for various features extracted

Ref. paper	Original Image	Extracted Image	Type of feature
[3]			Blood vessel Extracted
[2]			Blood vessel Extracted
[2]			Exudates Extracted
[7]			Exudates Extracted
[4]			Micro aneurysms Detected
[9]			Micro aneurysms Detected

4 CONCLUSION AND FUTURE WORK

From the review of the above papers, it can be concluded that many different techniques can be used for feature extraction from the fundus images. Initially it is always required to preprocess the image to increase the contrast and also to enhance the image so that the features can be extracted in a better and efficient manner. For detection of MA, green channel image provides better contrast. Post processing of the image can also be carried out for obtaining better results. In future, different preprocessing techniques can be used to enhance the fundus image and also different methods can be implemented to detect MA, blood vessels and exudates with higher accuracy.

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