FEATURES EXTRACTION OF FUNDUS PHOTOGRAPHS

Ms Shilpa S Joshi[1] , Dr. P.T. Karule[2]

[1,2]*Electronics Dept, Yashwantrao Chavan College of Engg, Nagpur Maharashtra (India)*

ABSTRACT

Due to the emerging number of diabetic retinopathy cases, accurate and efficient evaluations of the fundus images have become a serious burden for the ophthalmologists. The purpose is to develop an automatic computerized screening system for the localisation of the different features and lesions in a fundus retinal image to reduce the huge number or parameters that have to be extracted by ophthalmologist. Extraction, detection and identification of abnormalities have been one of the main focuses. A robust and computationally efficient approach to recognize automatically the main components of the retina and an important feature of background diabetic retinopathy is presented in this paper. Since many features have common intensity properties, geometric features and correlations are used to distinguish between them. The extraction is done in terms of many of the features such as the blood vessels, exudates and microaneurysms have detected quite accurately using different morphological operations applied appropriately. This paper has presented four main methods to succeed of retinal analysis. Firstly, the retinal images are pre-processed via adaptive, local, contrast enhancement. Secondly the main feature of a retinal image is defined as the blood vessels and its area calculation. Next the background diabetic retinopathy features are identified to detect the hard exudates. The microaneurysms are recognized by detecting all features similar to the blood vessels and removed the vessels out. Finally all information is accumulated. Extensive evaluation of the algorithm on a database of 254 images with varied contrast, illumination and disease stages. The images drawn by human expert are taken as the reference images for evaluation. The proposed algorithm has been shown to be a highly effective method for feature extraction and classification of fundus images. Results indicate 90.37% accuracy for identification. The proposed algorithm being simple and easy to implement, is best suited for fast processing applications.

Keywords- Blood Vessels, Exudates, Fundus Photograph, Mathematical Morphology, Microaneurysms

I. INTRODUCTION

Image processing, analysis and computer vision techniques are playing vital role in all fields of medical science and are especially pertinent to modern ophthalmology, as it is heavily dependent on visually oriented signs. Retinal digital images are obtained using fundus camera. Digital imaging systems can be processed to improve image quality and subjected to image analysis to perform objective quantitative analysis of fundal images and the potential for automated diagnosis. Automated diagnosis may also aid decision-making for optometrists. Automated detection of lesions in retinal images can assist in early diagnosis and screening of a common disease: Diabetic Retinopathy. Early diagnosis and timely treatment is vital to delay or prevent visual impair and even blindness. Currently, regular screenings are conducted. However, a large amount of images are obtained from these screenings and it requires trained ophthalmologists to spend a lot of time for manual analysis and diagnosis. Hence, automatic detection is desired as it can help to improve productivity and be more cost effective.

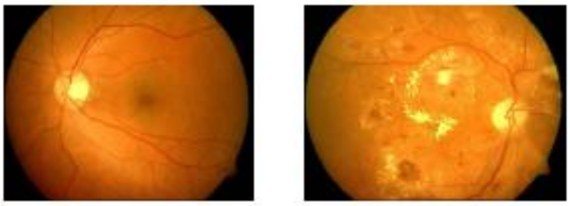

Fig 1. Normal Image and Abnormal image exhibiting microaneurysms and exudates.

Figure 1(a) shows a normal fundus image and Figure 1(b) shows a fundus image labelled in Diabetic Retinopathy exhibiting microaneurysms and exudates. The tasks for image processing may be divided into the following.

1.1 Automatic detection of features of the retina:

The blood vessel through the filter-based approaches include using a Laplacian kernel [1], and multiple applications of 2D Gaussian smoothing at different scales followed by ridge detection [2], [3], multi scale matched filter method [4], [5], 1D filters derived from Gaussian functions rotated at different angles, then retaining the largest magnitude response [6][7]. In [8] the authors have estimated the vessel profiles using a Gaussian function and its second derivative. In order to obtain a model for finding the vessel width, two methods: edge detection and matched filter have been proposed. Canny's method and gradient operator are used for detecting the edges of the vessel. In matched filtering, the vessel profile is convolved with the filter that is designed according to the model of the vessel profile. Once the matched vessel profile is found, diameter measurement is carried out using the parameters of the model. Matched filters are preferred as they help in eliminating the small branches at the bifurcation points. Detection and tracking of the blood vessels in the retinal images are carried out using Gaussian matched filters and Kalman filters in [9]. Gaussian matched filter has been used for locating the center and width of the vessel. Furthermore, Kalman filter is used for estimating the location of the next vessel segment based on the observed model, bifurcated vessels were also considered by these algorithms. In [10] the vessels in the retinal images are detected using two-dimensional matched filters. Operators are designed to take care of optical and special properties for the features of interest. The vessel profiles are assumed to be Gaussian and twelve different templates are used for searching vessel segments in all directions. These results are compared to other methods for validation. Walter et al [10] uses morphological operators to segment only the vascular tree of retinal angiograms. Feature detection is necessary for the identification of false positives in the pathology detection and for the classification of the pathologies in accordance with their severity.

1.2 Automatic detection of pathologies:

Microaneurysms([11]–[19]), hard exudates detection in fundus images based on a variety of techniques [18-20]. These techniques include image contrast analysis [21-23], Bayesian classifiers [24], [25], and neural networks [26], [27]. Because the brightness, contrast and color of exudates vary a lot among different patients and therefore different photographs. Measurements on the detected pathologies those are difficult or too time consuming to be done manually.

II. METHODOLOGY

2.1 Image pre-processing

RGB images require a three-dimensional array to convey the extra colour information. The first plane in the represents the red pixel intensities, the second plane represents the green pixel intensities and the third plane represents the blue pixel intensities. Often contrast is greater when the green channel alone is utilized in fundal image analysis as this enhances contrast between the background and features, such as blood vessels and microaneurysms. Each image was pre-processed to remove non-uniform background. Non uniform illumination and variation in the pigment color of the eye are two major reasons for this non-uniformity. This was corrected by applying adaptive histogram equalization to the image before applying the image processing operations. This technique adjusts the local variation in contrast by increasing the contrast in lower contrast area and lowering the contrast in high contrast area. Local contrast enhancement is a signal to noise enhancement process to create images which are improved for the subsequent retinal blood vessel detection. It emphasizes the local contrast of the intensity values of an image so that the blood vessels are more clearly distinguished from the background. From visual observation, blood vessels generally exhibit the greatest contrast from the background in the green band and therefore the green band is selected from the contrast enhanced images for further processing.

2.2. Recognition of main retinal component

Retinal blood vessels are one of the most important components in ophthalmic diagnosis. Blood vessels appeared as networks of either deep red or orange-red filaments that originated within the optic disc and were of progressively diminishing width. The method proposed by Nayak J., Bhat S, was adapted in the detection of blood vessel in this work which was done on fewer images [28]. Detecting abnormalities such as venous looping or beadings is critical for early treatment as they are in most cases indication of potentially sight-threatening retinopathy. In order to utilize these sell characteristics of retinal blood vessels, it is very important to obtain their locations and shapes along with its area calculation accurately. In many of the reported studies on automatic fundus image analysis and diagnosis normal components within the image, such as blood vessels are detected and identified before starting abnormal component detection. Pathologies such micro aneurysms or haemorrhages, located close to blood vessels, may be misclassified as blood vessels and removed in the pre-processing, resulting in reduced specificity of pathology detection and hence possible misdiagnosis. Accurate retinal blood vessel extraction is therefore required as a pre-processing component of an automatic diagnosis/screening system. In this paper, we extract the blood vessel of different thickness using morphological operations open and close.

2.3 Mathematical Morphology

Morphological image processing is a type of processing in which the spatial form or structure of objects within an image is modified. Morphological operations are a set of image processing operations that analyses the shapes within the image. It applies a structuring element to the image and output the image of the same size. The output value of each pixel is determined by the neighbouring pixels with its corresponding pixel of input image. The size and shape of the structuring element affects the number of pixels being added or removed from the object in the image. Closing operation is defined as dilation (Max filter) followed by erosion (Min filter).Dilation is an operation that grows or thickens objects in a binary image. The specific manner and extent of this thickening is controlled by a shape referred to a structuring element. Dilation is defined in terms of set operation as

$$A \oplus B = A1(x, y) = \max(A(x-i, y-j) + B(i, j))i, j \in B \qquad (1)$$

Erosion shrinks or thins objects in a binary image. The manner and extent of shrinking is controlled by a structuring element. The erosion of A by B is defined as

$$A \Theta B = A2(x, y) = \min(A(x-i, y-j) + B(i, j))i, j \in B1 \qquad (2)$$

We are using disk shaped structuring element for morphological operation. Dilation in gray scale enlarges brighter regions and closes small dark regions. The erosion is necessary to shrink the dilated objects back to their original size and shape. The dark regions closed by dilation do not respond to erosion. Thus, the vessels being thin dark segments laid out on a brighter background are closed by such a closing operation. The shape and size of SE is set according to image structures that are to be extracted and SE determined by prior knowledge through visually examining images. Then the image through smoothing filter was input for the edge detection technique. The results of edge detection was compared with the image passing before and after the smoothing filter and results were found better for the edge detection technique applied on filtered images. Similarly, we tested the image on different edge detection technique like Gaussian Laplacian, Prewit edge operator, Sobel's Operator. To our surprise, it was found that Canny's edge detection technique was the best amongst the other edge detection technique. Reason, it uses two thresholds for detecting the edges and as a result both strong and weak edges are detected and its area is calculated.

2.4 Exudates Detection

The significant changes during the disease are the formation of exudates; rather symptom of the disease is indeed the formation of exudates. Exudates literally means that any fluid that filters circulatory system into lesions or areas of inflammation. Exudates appear as bright patterns in retinal images. They are manifested as random whitish/yellowish patches of varying sizes, shapes and location. Exudates are made up of serum lipo proteins. The method proposed by Walter was adapted in the detection of exudates in this work [24].

High contrast vessels are eliminated first by a closing operator before local variation operator is applied. The resulting image is threshold to get rid of all regions with low local variation. To ensure that all the neighbouring pixels are also included in the candidate region, dilation operator is also applied. The result image is used as a mask, showing all possible candidate regions of exudates. The Exudates detection areas are obtained by applying a threshold operator to the difference between the original image and the reconstructed image. Exudates have the potential of occurring as noise in the vessel segmentation because closing and subtracting the

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irregularly shaped exudates using regular structuring elements is not an exact operation (i.e. the shape of exudates does not remain the same after the closing operation). Hence, we perform an additional step to overcome this limitation. The result of the exudates detection algorithm is dilated and subtracted from the blood vessel result. This removes any noise due to exudates in the extraction of the main blood vessel. By applying AND logic, the non-exudates regions are set to binary 0 (black) and exudates are binary 1 (white). As a result, the exudates area is obtained.

2.5 Microaneurysms Detection

Microaneurysms are the first clinically observable signs of diabetic retinopathy. Microaneurysms appear as small, round hyper fluorescent objects in visible images of the retina. There exists a positive correlation between the number of Microaneurysms in the image with both the severity and the likely progression of the disease. Microaneurysms are small vascular pouches caused by local distension of capillary walls and appear as small red dots. This may also lead to big blood clots called haemorrhages. By applying the morphological operation on the image and doing the comparison with AND logic the final microaneurysms image is obtained after removing the small noise, blood vessel, exudates and optical disk area and its area calculation is done. The features such as blood vessel, exudates and microaneurysms can be detected quite accurately using morphological operations applied appropriately. Finally all information is accumulated and the classification is done as normal and abnormal on the basis of exudates and corresponding microaneurysms detection. Lastly, a Graphical User Interface (GUI) to access the automated program would be developed and all the findings and results would be recorded and documented.

III. RESULTS

Below figures shows some sample results from DRIVE, diaretdb0 and diaretdb1 databases using the proposed algorithm. The results demonstrated herein indicate that automated identification of main retinal component based on Morphological operation can be very successful. Hence, eye care specialists can potentially monitor larger populations using this method. Extensive evaluation of the algorithm on a database of 254 images with varied contrast, illumination and disease stages. This algorithm is apply on publicly available DRIVE, diaretdb0, diaretdb1 databases.The images drawn by human expert are taken as the reference images for evaluation. Results indicates 90.37% accuracy for Identification.

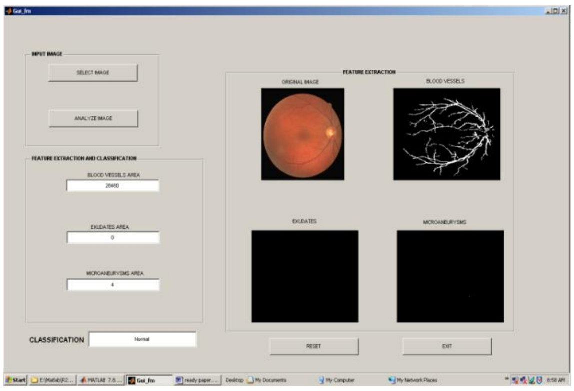

Figure 2. Result of DRIVE Training database Image-Normal

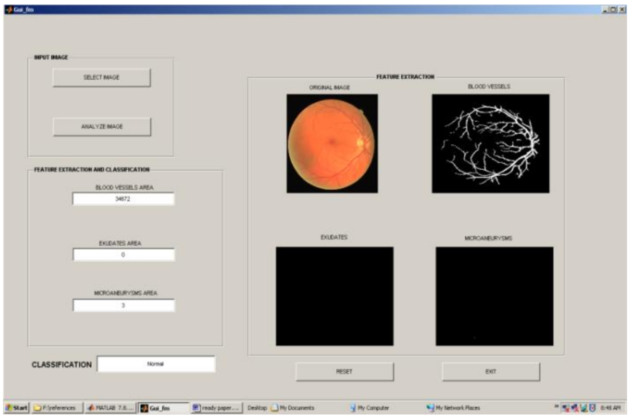

Figure 3. Result of DRIVE Testing database Image-Normal

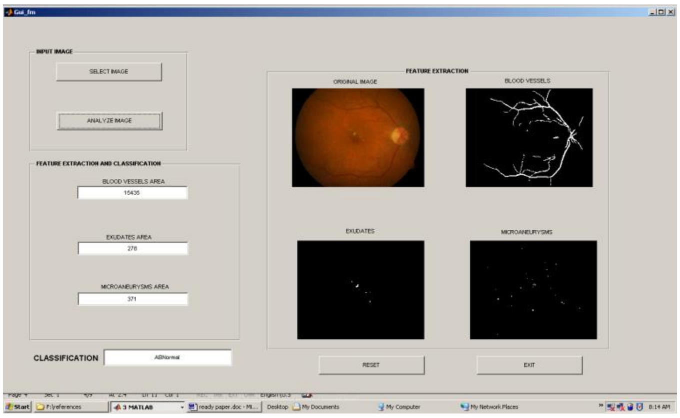

Figure 4. Result of diaretdb0 database Image-Abnormal

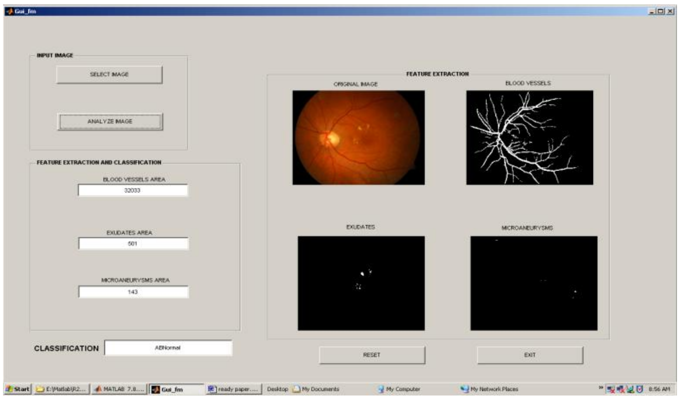

Figure 5. Result of diaretdb1 database Image-Abnormal

IV. CONCLUSION

The techniques describe in the paper is based on morphological operation and apply on a large number of images. In this paper, a simple and computationally efficient algorithm for retinal feature extraction has been presented. Our proposed technique does not require any user intervention, and has consistent performance in both normal and abnormal images. The development of getting higher performance is in progress.

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