Automated Detection of Abnormalities in Retinal Images

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***Abstract*—Detection of basic differentiating characteristics of eye diseases from the images of the retina can be a good approach as a low-cost method for broad-based initial screening. The extraction of retinal vessels plays an important role in the diagnosis and analysis of retinal diseases, such as Age-related Macular Degeneration (AMD), Diabetic Retinopathy, retinitis pigmentosa. The blood vessels are the part of the circulatory system that transports blood throughout the body. Automated approach for detection of microaneurysms in digital color retinal fundus photographs helps ophthalmologist to detect the emergence of its initial symptoms and determine the next immediate action step for the Diabetic patients. A similar mechanism for automated early disease detection method is proposed featuring identification of dark pigments like minute features, exudate and microaneurysm detection and these features extracted can prove to a greater extent as primary instances for defectiveness of eye. The color retinal images were segmented using fuzzy C-means clustering followed by some key preprocessing steps.**

Keywords— Age-related Macular Degeneration (AMD), Diabetic Retinopathy, Retinitis pigmentosa, microaneurysms, opthalmologist.

I. INTRODUCTION

The blood vessels are the part of the circulatory system that transports blood throughout the body. There are three major types of blood vessels the arteries, which carry the blood away from the heart; the capillaries, which enable the actual exchange of water and chemicals between the blood and the tissues; and the veins, which carry blood from the capillaries back towards the heart. Blood vessels do not actively engage in the transport of blood (they have no appreciable peristalsis), but arteries and veins to a degree can regulate their inner diameter by contraction of the muscular layer. This changes the blood flow to downstream organs, and is determined by the autonomic nervous system. Vasodilatation and vasoconstriction are also used antagonistically as methods of thermoregulation.[1]. The proposed system referenced three diseases diabetic retinopathy, retinitis pigmentosa, age related macular degeneration. Earl stage Diabetic retinopathy is detected by exudates which often present in the retinal image this is happen by blood vessels edema. Retinitis pigmentosa disease identified by black pigments present in the retina. The final disease Age Related macular degeneration detected by drusen feature(white colored rounded dots).

II.. RETINAL DISEASES

A. Diabetic Retinopathy

Diabetic retinopathy is a complication of diabetes mellitus. It is the most common cause of blindness worldwide. Although diabetes itself cannot be prevented, complications such as blindness can be moderated if the disease is diagnosed early.[2] The most effective method currently is regular screening of the fundus to detect early signs of diabetic retinopathy. Microaneurysms – tiny dilations of the blood vessels - are the first unequivocal sign of diabetic retinopathy so that their detection in fundus images through photography might be enough to detect the disease in an early stage. However, with a large number of patients undergoing regular screenings, tremendous amount of time is needed for the medical professionals to analyze and diagnose the fundus photographs. By automating the initial task of analyzing the huge amount of retinal photographs for symptoms of diabetic retinopathy, the efficiency of the screening process can be greatly improved. At the same time, patients that require the attention of the ophthalmologist would be timely referred.

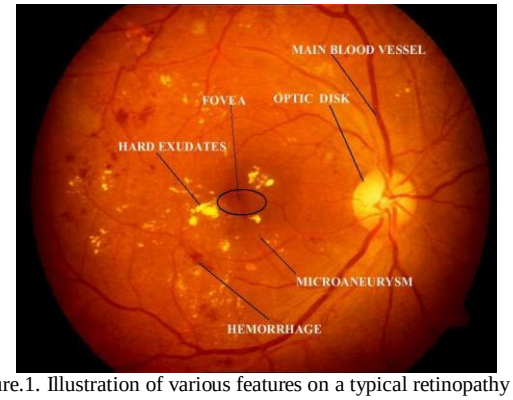

Figure.1. Illustration of various features on a typical retinopathy image.

Color fundus images are used by ophthalmologists to study eye diseases like diabetic retinopathy. Figure 1 shows a typical retinal image labeled with various feature components of Diabetic Retinopathy. Microaneurysms are small saccular pouches caused by local distension of capillary walls and appear as small red dots[3]. This may also lead to big blood clots called hemorrhages. Hard exudates are yellow lipid deposits which appear as bright yellow lesions. The bright circular region from where the blood vessels emanate is called the optic disk. The fovea defines the center of the retina, and is the region of highest visual acuity. The spatial distribution of exudates and microaneurysm and hemorrhages, especially in relation to the fovea can be used to determine the severity of diabetic retinopathy.

B. Age related macular degeneration

Age related macular degeneration often called AMD or ARMD, is a deterioration or breakdown of the eye's macula. AMD is the leading cause of the vision loss and blindness who are all at age 65 and older. Because people in these group are increasingly large percentage of the general population, vision loss from macular degeneration is a growing problem. The macula is a small area in the retina – the light- sensitive tissue lining the back of the eye. The macula is the part of the retina that responsible for your central vision, allowing you to see fine details clearly. Types of macular degeneration: dry macular degeneration and wet macular degeneration.[4].


Figure.2. Illustration of drusen feature present in age related macular degeneration diseased image.

C. Retinitis pigmentosa

Retinitis pigmentosa (RP) is a generic term for a group of disorders characterized by hereditary diffuse usually bilaterally symmetrical progressive dysfunction, cell loss and eventual atrophy of retina. Initially photoreceptors are involved and subsequently inner retina is damaged. Although both rods and cones are involved, damage to the rods is predominant. RP may be seen in isolation [5]. (Typical RP) or in association with systemic diseases. The reported prevalence of typical RP is approximately 1: 50000 worldwide. Retinitis pigmentosa (RP) affect the retina's ability to respond to light. This inherited disease causes a slow loss of vision, beginning with decreased night vision and loss of peripheral (side) vision. Eventually, blindness results. Unfortunately, there is no cure for RP[6].

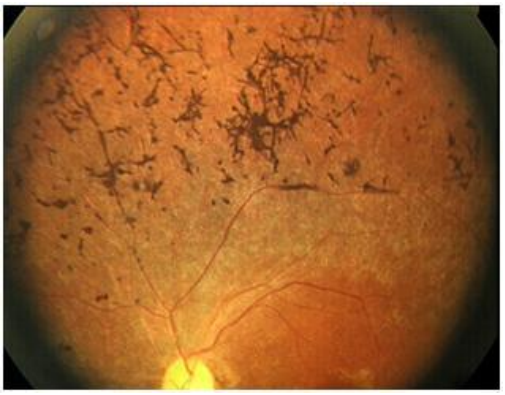
Figure.3. Illustration of dark pigments present in retinitis pigmentosa diseased image.

III. WORK FLOW

A. *Image Acquisition*

Normal and abnormal images are obtained from the High-Resolution Fundus (HRF) Image Database[7].This database has been established by a collaborative research group to support comparative studies on automatic segmentation algorithms on retinal fundus images. The database is provided by the Pattern Recognition Lab (CS5), the Department of Ophthalmology, Friedrich-Alexander University Erlangen-Nuremberg (Germany), and the Brno University of Technology, Faculty of Electrical Engineering and Communication, Department of Biomedical Engineering, Brno (Czech Republic).

Retinitis pigmentosa and age macular degeneration retinal images were obtained from the retinal image bank.[8]

B. *Retinitis pigmentosa*

1) Color Plane Extraction

An RGB image, sometimes referred to as a true color image, is stored in MATLAB as an m-by -n-by -3 data array that defines red, green, and blue color components for each individual pixel. RGB images do not use a palette. The color of each pixel is determined by the combination of the red, green, and blue intensities stored in each color plane at the pixel's location. From survey it has been found that color

retinal image has unique characteristic than other image.[9]

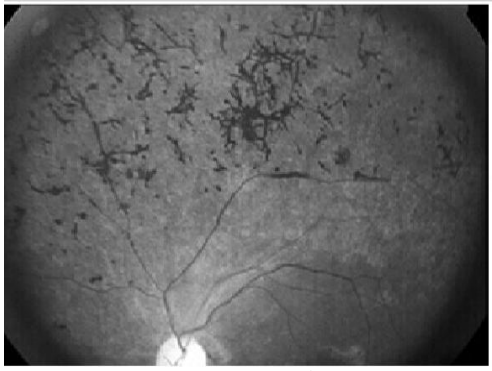

Figure.4. Green channel image of the input image.

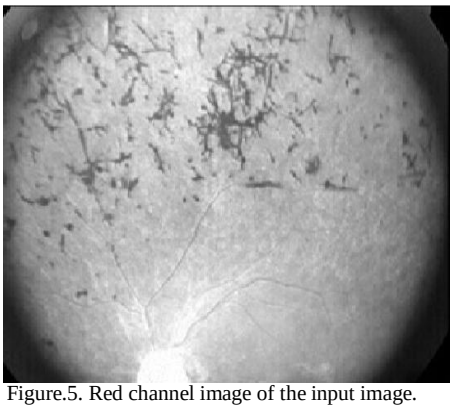

Figure.5. Red channel image of the input image.

2) Sobel edge detection

The Method parameter, selected as Sobel detects block and finds the edges in an red component input image (Figure 4 and Figure 5 explains the reason behind the specific choice of Red Component instead of Green or Blue Component) by approximating the gradient magnitude of the image. The block convolves the input matrix with the Sobel. The block outputs two gradient components of the image, which are the result of this convolution operation. Alternatively, the block can perform a thresholding operation on the gradient magnitudes and output a binary image, which is a matrix of Boolean values. If a pixel value is 1, it is an edge.

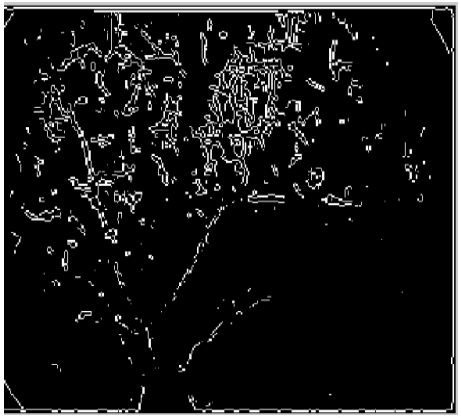

Figure.6. Sobel method applied to Red Plane. This figure serves better for further analysis because of clear detection of defective region.

3) Working with ROI (Region of Interest)

In this process the region of interest (ROI) is calculated by interpolating the pixel values from the borders of the region. This process can be used to make objects in an image seem to disappear as they are replaced with values that blend in with the background area. With respect to the green component, region of interest are determined using set of threshold values gather on a real time scenario. However this set of threshold values can be subjected to alteration based on a self-learning methodology as a part of future scenario

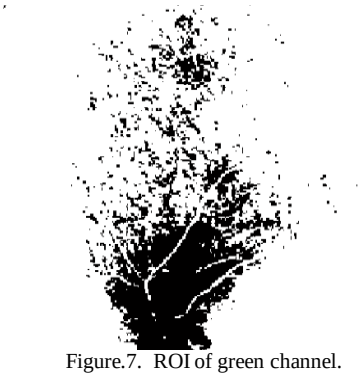

Figure.7. ROI of green channel.

4) Fusion of images from 3.3 and 3.4

For achieving the fusion mechanism the images obtained from step 3.3 and step 3.4 have been plotted to a zero matrix of dimension equal to the input images and the result, so obtained displays the affected areas highlighted as white pixels.

Figure.8.Output fusion image of figure 6 and figure 7.

C. Diabetic retinopathy

Various edge detection methods are used to detect the early stage of diabetic retinopathy. Edge detection methods are sobel,cann,prewitt and edge otsu. Those methods are applies to the input image to have the blood vessels accurately. Exudates are separated from the background image by segmenting the blood vessels.[10]

Figure.9.Input image of Diabetic retinopathy having exudates.

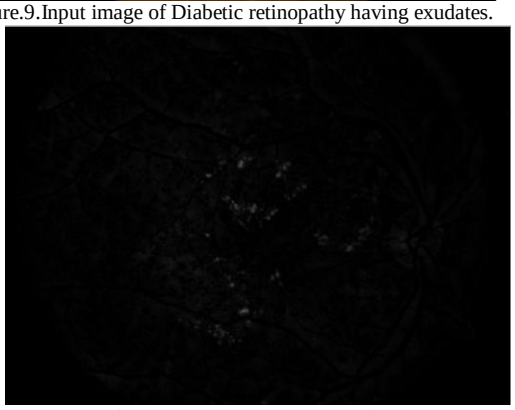

Figure.10. Illustration of exudates which is separated from the background.

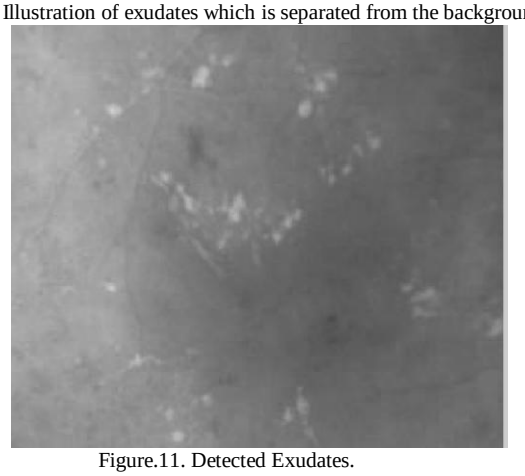

Figure.11. Detected Exudates.

D. *Age related macular degeneration*

Optic disk is separated for this disease to detect the abnormalities. Drusen feature is present in the retinal image so that drusen is detected by using edge detection procedure. Combinations of both factors are used to identify the age related macular degeneration.

Figure.12. Detected Drusen.

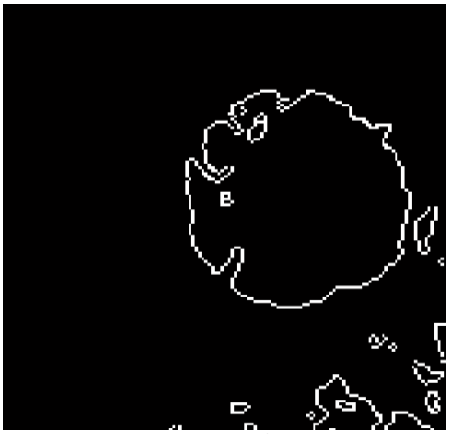

Figure.13. optic disk is extracted for the input image.

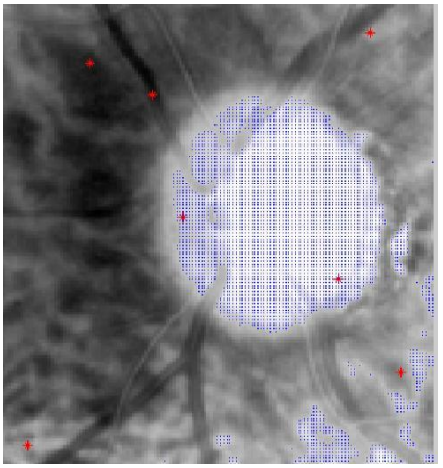

Figure.14. optic disk is denoted in the blue region.

IV. RESULTS

Matlab results are shown accordingly with method described in previous discussions. We used a dataset of 200 images for evaluating the algorithm. The images were obtained from diverse sources and hence have sufficient variations in color, illumination and quality. The various sources of the images are as follows: High-Resolution Fundus (HRF) Image Database and Retinal image database.

Figure 8 shows the black pigments that denote those images are defected from Retinitis pigmentosa disease. Figure 9 and figure 10 shows the exudates that denotes diabetic retinopathy in early condition similarly for age related macular

degeneration drusen and optic disk are obtained that is shown in figure 12 and figure 13.

V. CONCLUSION

Widely observed results from the present work helped to get an insight into the perfection of detection. In this work, an efficient framework for early detection of Diabetic Retinopathy has been developed. The optic disk is tracked by combining the blood vessel convergence and high disk intensity properties in a cost function. We show that, as opposed to most methods that use learning techniques, geometrical relationships of different features and lesions can be used along with simple morphological operations in order to obtain a very robust system for analysis of retinal images. Our techniques may further be combined with some learning methods for possibly even better results.

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