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Detection and Analysis of Microanuerysm in Diabetic Retinopathy using Fundus Image Processing

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Abstract: Diabetic-related eye disease is a major cause of blindness in the world. It is a complication of diabetes which can also affect various parts of the body. When the small blood vessels have a high level of glucose in the retina, the vision will be blurred and can cause blindness eventually, which is known as diabetic retinopathy. Detection of the disease at an early stage enables the patient to get treatment by advanced methods like laser treatment to prevent total blindness. The paper deals with detecting the diabetic retinopathy retinal changes. The retinal images are first subjected to pre-processing techniques like colour normalization and enhancement process. There may exist different kinds of lesions caused by diabetic retinopathy in a diabetic patient's eye such as micro aneurysm, hard exudates, soft exudates, hemorrhage etc. Automated analysis of the fundus (retinal image) image is very much essential and will be of help to facilitate the clinical diagnosis.

Keywords: Diabetic Retinopathy; Exudates; Haemorrhages; Micro Aneurysm.

I. INTRODUCTION

Diabetic retinopathy (DR) is one of the complications resulted from prolonged diabetic condition usually after ten to fifteen years of having diabetes. In the case of DR, the high glucose level or hyperglycemia causes damage to the tiny blood vessels inside the retina. These tiny blood vessels will leak blood and fluid on the retina, forming features such as a Microaneurysms, hemorrhages, hard exudates, cotton wool spots, or venous loops. [4].

DR affects about 60% of patients having diabetes for 15 years or more and a percentage of these are at risk of developing blindness discussed in [8]. Despite these intimidating statistics, research indicates that at least 90% of these new cases could be reduced if there were proper and vigilant treatment and monitoring of the eyes [11]. Laser photocoagulation is an example of a surgical method that can reduce the risk of blindness in people who have proliferative retinopathy [12]. However, it is of vital importance for diabetic patients to have regular eye checkups. Current examination methods use to detect and grade retinopathy include ophthalmoscope (indirect and direct) James L. Kinyoun et al [13], photography (fundus images) and fluorescein angiography. The objective of this project is to implement an automated detection of diabetic retinopathy (DR) using digital fundus images. By using MATLAB to extract and detect the features such as blood vessels, Microaneurysms and exudates which will determine classifications: normal or abnormal (DR) eye. An early detection of diabetic retinopathy enables medication or laser therapy to be performed to prevent or delay visual loss.

Diabetic retinopathy occurs when blood vessels of the retina in the posterior part of the eye are damaged. Damages due to small vessels would be known as microvascular disease while damages due to the arteries would be a macrovascular disease. Generally, diabetic retinopathy is classified mainly as non-proliferative diabetes retinopathy (NPDR) and proliferative diabetes retinopathy (PDR).The proposed system extracts the clinical features of diabetic retinopathy. The clinical features include blood vessels, exudates, Microanuerysm etc. This work is aimed to develop a system to analyze the retinal images for extracting important features of retinopathy using the image processing methods [2].

II.CLINICAL FEATURES OF DIABETIC RETINOPATHY

The progressive nature of DR, if not properly treated increases the peril with the increasing age of the patient [3].and it might eventually lead to loss of vision. DR occurrence has been generally categorized into three main phases and these are as explained subsequently.

1) Background Diabetic Retinopathy (BDR): In this phase, the arteries in the retina become weak and start to leak, forming small, dot-like bodies called Hemorrhages. These leaking vessels often lead to swelling or edema in the retina and decreased vision.

2) Proliferate Diabetic Retinopathy (PDR): In this phase, circulation problems cause areas of the retina to become oxygen-deprived or ischemic. New fragile, vessels develop as the circulatory system attempts to maintain adequate
Oxygen levels within the retina. This phenomenon is called Neovascularisation. Blood may leak into the retina and vitreous, causing spots or floaters, along with decreased vision.

3) Severe Diabetic Retinopathy (SDR): In this phase, there is continued abnormal vessel growth and scar tissue, which may cause serious problems such as retinal detachment and glaucoma and gradual loss of vision.

These three phases can occur with any of the following artifacts:

1) Microanuerysms: These are the first clinical abnormality to be noticed in the eye. They may appear in isolation or in clusters as tiny, dark red spots or looking like tiny Haemorrhages within the retina light sensitive area. Their sizes range from10-100microns and are circular in shape [3]. At this stage, the disease is not yet eye threatening.

2) Hemorrhages: Occur in the deeper layers of the retina and are often called blot Haemorrhages because of their round shape.

3) Hard Exudates: This is one of the main characteristics of DR. It can vary in size from tiny specks to large patches with clear edges. These can impair vision by preventing light from reaching the retina
.
4) Soft Exudates: Soft exudates of pale yellow-white in color are often called cotton wool spots. Their shapes are round or oval and are formed as a result of capillary occlusions which lead to the permanent damage of the retina functions [3].

III.FEATURE EXTRACTION

There are several risk factors that make it more possible for a diabetic patient to develop diabetic retinopathy the most important one is the duration of diabetes, since retinopathy does not appear suddenly, but it takes several years to develop. Almost all of Type 1 and about half of Type 2 diabetics have some degree of retinopathy when they have had diabetes for 20 years. Another risk factor is the high level of blood glucose, which harms the blood vessels of the retina and disturbs their activity. Other risk factors are high blood pressure, increased level of blood lipids, smoking, and pregnancy. The proposed system includes the feature selection of the retinal image by detecting the exudates (soft and hard), blood vessels, Microaneurysms, optic disc, and hemorrhages. The block diagram describing the proposed system is shown in figure 1.

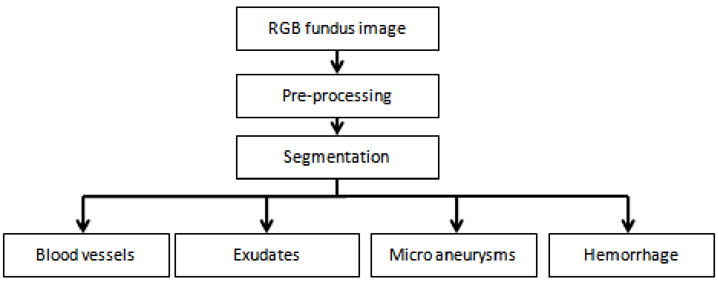


Figure 1-Feature Extraction

The main objective of this project work is to detect the early stage of DR using the features extracted from the pre-processed image [3]. The image obtained from the database is subjected to the pre-processing steps such as green channel extraction, contrast enhancement, median filtering and histogram equalization [5]. After pre-processing, the image is morphologically operated by a disk shaped structuring element [1]. The connected component analysis method is used for the removal of optic disk [10]. This image is then utilized for feature extraction. The features like Microanuerysms area, homogeneity and texture properties are extracted [6], the appropriate features for classification are selected.

IV.DETECTION OF MICROANUERYSMS

Microaneurysms indicate the first sign of diabetic retinopathy. They appear as small red dots on the fundus image. More the number of dots, the disease may be severe. Microanuerysms might be temporary or permanent changes, sometimes they might appear temporarily and then disappear. The block diagram for detecting Microaneurysms is as shown in figure 2.

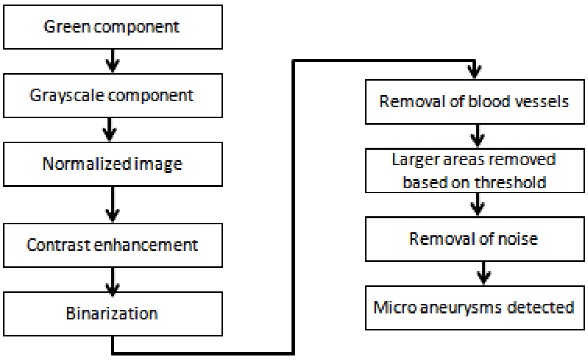


Figure 2-Detection of Microanuerysms

4.1 Image Acquisition

The proposed methodology is explained below. In this method, a dataset of manually labeled images is taken. This dataset consists of images taken from a screening program for DR in Aditya Jyot eye Hospital, Mumbai. Several images were taken for trial purpose in the dataset, few of patients with abnormal (contains Microanuerysms) and few of the images are normal.

2.2 Pre-processing

Pre-processing is the initial step in all the case of image related diagnosis system and it helps in accurate feature extraction. In the case of Diabetic Retinopathy, the retinal images in the dataset are often noisy and poorly illuminated because of unknown noise and camera settings. Also, the colour of retina has wide variation from patient to patient. Thus to remove noise and undesired region the images are subjected to pre-processing steps, which include green channel extraction, histogram equalization and contrast enhancement

2.2.1 Green Channel Extraction

In the green channel of colour images, MAs appear as dark patterns, small, isolated and of circular shape. The green channel is the most contrasted one, that the red channel is saturated and that the blue channel does not contain any information [3]. Green light is less absorbed by the fundus layers than the blue part of the spectrum, but more than red light, which penetrates deeper into the layers of the inner eye and which is mainly reflected in the choroid. The red light is less absorbed by the pigments of the inner eye, and it dominates the reflected spectrum. This is the reason why the colour fundus images appear reddish. Because of the lower absorption coefficients for a red light, structures containing pigments are less contrasted than it is the case for the green light. This does not mean that there cannot be any useful information in the red and blue channel. It just means that blood containing elements (as MA or vessels) in the retinal layer are best represented and have the highest contrast in the green channel [5].

2.2.2 Histogram Equalization

Histogram equalization is defined as the process of adjusting intensity values of the image [3]. Here contrast-limited adaptive histogram equalization (CLAHE) is performed. Unlike histogram equalization, it operates on small data regions (tiles) rather than the entire image. Each tile's contrast is enhanced so that the histogram of each output region approximately matches the specified histogram (uniform distribution by default). The contrast enhancement can be limited in order to avoid the amplification of noise which might be present in the image [1].

2.2.3 Filtering

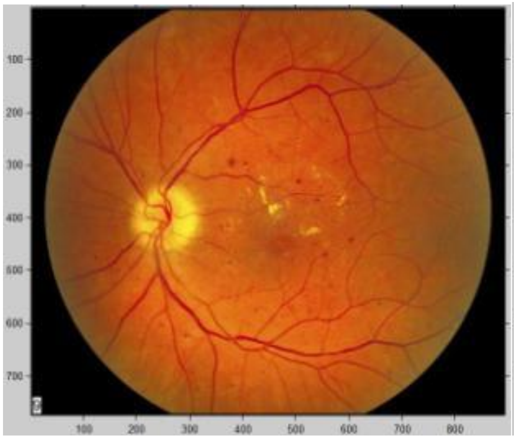
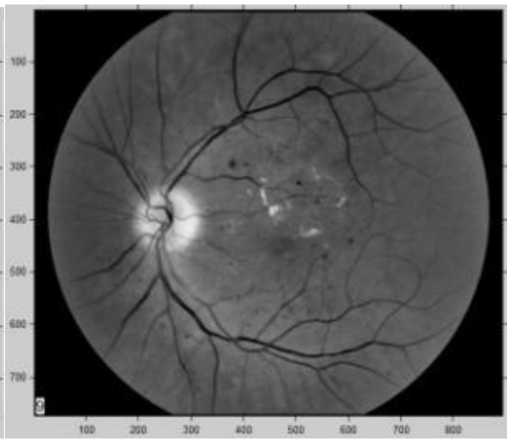
The necessity of filtering the histogram equalized image is to suppress the background pixels along the Microanuerysm pixels. Here a 3x3 median filter is used to remove the poorly illuminated pixels [3]

2.2.4 Contrast Enhancement

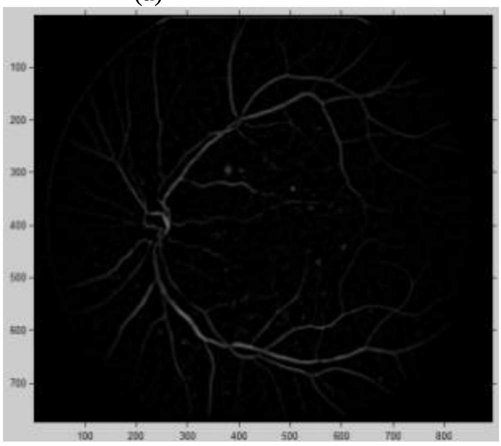
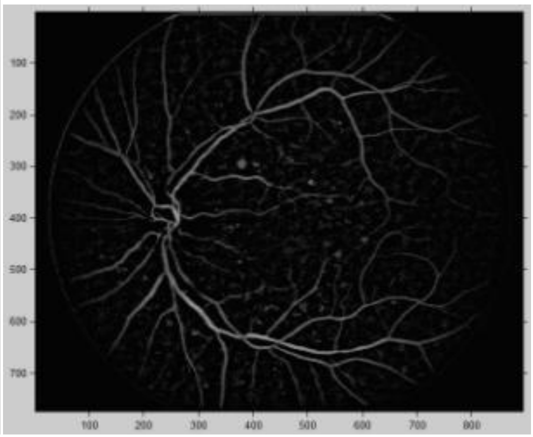
It is essential to distinguish the MAs from the blood vessels and background of the image [2]. For this purpose, Contrast enhancement step is used in the pre-processing to enhance the contrast of the Microanuerysms. This process facilitates the image for further processing.

2.2.5 Morphological Operation

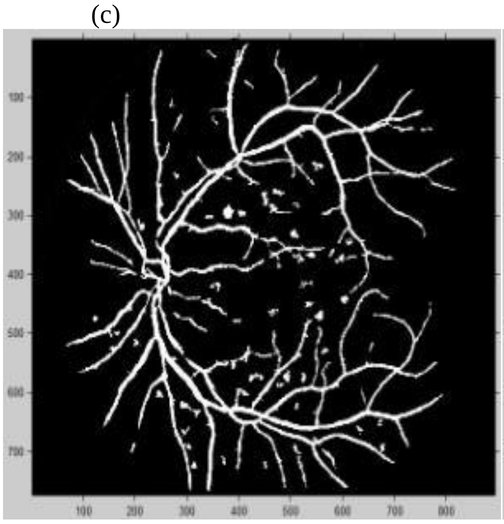
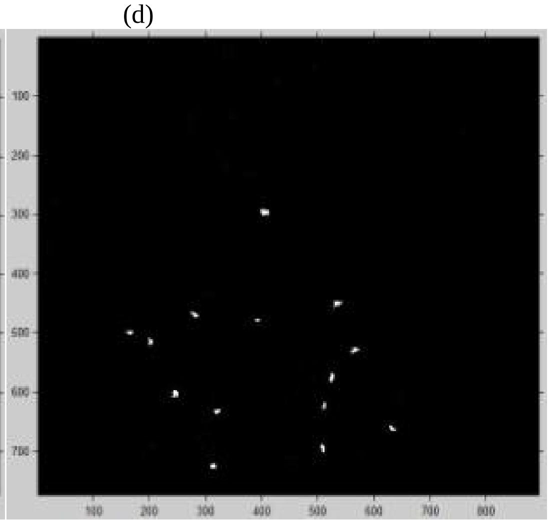
The contrast enhanced image is then converted to a binary image by applying proper thresholding value. This binary image is subjected to morphological operations i.e. opening and closing [1]. Closing operation is defined as dilation and opening as erosion. Dilation is an operation that grows or thickens objects in a binary image. Erosion shrinks or thinks the objects in the binary image [3]. Structuring element is defined as the shape (dimension) that controls the process of thickening and thinning [5]. As the optic disk and Microanuerysms are circular in shape, a disk shape structuring element is used in this project.

(a) (b)

(c) (d)

(e) (f)

Fig 3: (a) RGB image with MAs, (b) Green channel of Microanuerysm image (c) Filtered Microanuerysm image (d) Histogram equalized image (e) Image with MAs and blood vessels (f) Image with MAs

CONCLUSIONS

Every year the vision loss due to diabetic related eye diseases are seen to increase. Nowadays the detection of the disease is done by a trained ophthalmologist. In this paper, the presences of abnormalities in the retina are detected using image processing techniques. The simulation is done in Matlab R2007b.As a future work, the detection of retinal abnormalities due to diabetic retinopathy is done using fuzzy logic where the severity of the disease can also be indicated.

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