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Automatic Detection and Analysing Severity of Diabetic Retinopathy Disease using Retinal Images

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Abstract

Diabetic Retinopathy is an eye threatening disease which not treated properly may lead to loss of vision. This may occur to patients who are suffering from diabetes for a long duration. The less controlled of blood sugar level may eventually lead to Diabetic Retinopathy. Extraction of blood vessels, hard exudates and microaneurysms are the three ways of identifying this disease. The area of these extracted features is calculated for examining whether the person is affected by the disease. Also the severity of the disease can also be found by the number of white pixels appearing in the extracted image wherein the area of the hard exudates and microaneurysms exceeds a certain threshold, provides a corresponding treatment for the disease. Fundus camera captures the retinal images. With the help of acquired retinal images automated screening of these images can be accomplished. Also it is possible to rectify the associated complications in the retina of the eye. The advantage is that the detection and analysing of this disease can prevent the permanent visual loss and provide a proper treatment to the patients who are suffering from this disease.

Keywords:diabetes, blood vessels, hard exudates, microaneurysms, fundus camera

Introduction

Diabetic Retinopathy (DR) is a serious complication associated with the eyes. Diabetic Retinopathy consists of two terms, Diabetes and Retinopathy. Diabetes is a disease in which the patient is suffering from high sugar level because of low insulin production. Retinopathy is associated with the retinal damage. This may occur because the patient suffering from diabetes for a long duration and it is less controlled blood sugar level. The early detection of DR may prevent vision loss and blindness [1]. The irregularities and leakage of blood vessels may eventually lead to blindness when it's severe [2]. This is mainly because of the elevated blood sugar level which affect the lining of the blood vessels in eyes causing them to thicken and develop leaks. The poor circulation of the blood in the retinal blood vessels can add to these problems and thereby producing a new fragile vessels and which interferes with the normal vision. The other problem associated with diabetic retinopathy is the formation of the hard exudates [3]. This is one of the main characteristic associated with diabetic retinopathy which can vary in size from tiny specs to large patches. Hard exudates appear as yellow bright lesions which are deposits of yellow lipids. This can impair vision from preventing light entering the retina [4]. The bright circular region from where blood originate is called optic disc. The first clinical abnormality observed in the eye is Microaneurysms [5]. They typically appear in clusters or in isolations as tiny, dark red spots or look like haemorrhage in the light sensitive retina. These are less than $1/12^{th}$ the size of optic discs and their sizes may vary from the range 10-100 micron. To detect these problems associated with the eye there is a requirement of automated screening of the patients suffering from diabetic retinopathy. First step is acquiring the image. This can be accomplished with the help of fundus camera. This basically consists of specialized low power microscope with an attached camera. It can capture interior surface of the eye, including retina, optic disc, macula and posterior pole. Fundus camera are usually operated by optometrists and ophthalmologists and trained medical professionals for monitoring progression of the disease or in screening where these captured images can be analysed later. JPG is the format of those acquired images. With the help of acquired retinal images automated screening of these images

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and rectify the associated complications in the retina of the eye can be accomplished [6].

LITERATURE SURVEY

The abnormalities with the eye can be catagorized into two classes.

1. Disease of the eye due to glaucoma, cataract and conjunctivitis.
2. The disease due to life style related such as arteriosclerosis, hypertension and diabetes.

Diabetic Retinopathy can be categorized mainly into two types

1. Non-Proliferative Diabetic Retinopathy: Also known as background retinopathy. The retinal capillaries get damaged and microscopic leaks occur in these vessels. This leak eventually causes the swelling in the retina which interferes with the normal vision.Early detection in this stage is not threatening to the central vision.

2. Proliferative Diabetic Retinopathy: The capillaries of the retina shut down causing a new blood vessel to grow. There is an abnormal growth of the blood vessel in the retina. This mainly occur due to the lack of oxygen in the retina causes new fragile, blood vessels to grow along the retina of the eye and in the clear-gel like vitreous humour that fills inside the eye. Without periodic treatment, these new blood vessels can bleed, block vision and destroy the retina. Vitreous haemorrhages may block passage of the light entering the retina causing loss of vision and eventually blindness may occur. In addition, these new fragile blood vessel cause scar tissue that may pull out the retina and cause the detachment of retina from back of the eye.

The symptoms of Diabetic Retinopathy are:

1. The spots in the area of vision
2. Vision blurred
3. A dark or an empty spot in the centre of the vision
4. Difficulty in seeing well during nights.

With the patients with prolonged diabetes and less the sugar level is controlled are prone to suffer from diabetic retinopathy.

METHODOLOGY

The fig 1 shows the block diagram that depicts the ways of finding the diabetic retinopathy.

The retinal images are obtained from the fundus camera and it is undergoing further processing for detecting if any abnormalities are present in the eye.

The detection mainly consists of

1. Detection of Blood Vessels
2. Detection of Hard Exudates
3. Detection of Microaneurysms

And also by calculating the extracted area of the blood vessels, hard exudates and microaneurysms, an inference can be obtained whether the patient is suffering from diabetic retinopathy. The number of white pixels appearing in the image provides the area affected by Diabetic Retinopathy. Severity can also be analysed and provide a corresponding treatment accordingly. If the area of the hard exudates and microaneurysms exceeds certain threshold then a suitable treatment can be provided with the automated method of screening of the retinal images.

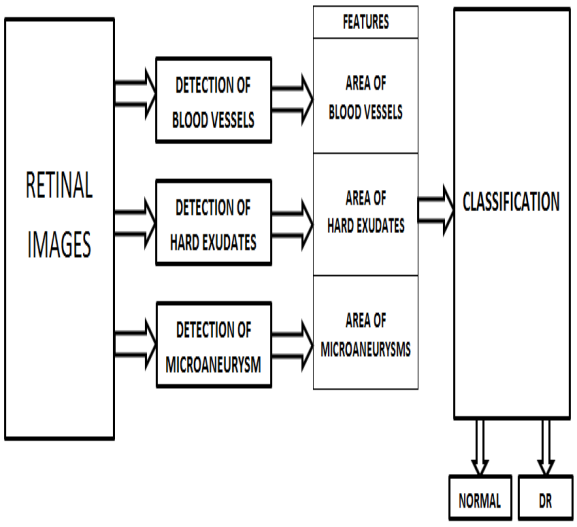

Figure 1: Block Diagram

The classification stage classifies the image as normal or affected based on extracted features.

A. Detection of Blood Vessels

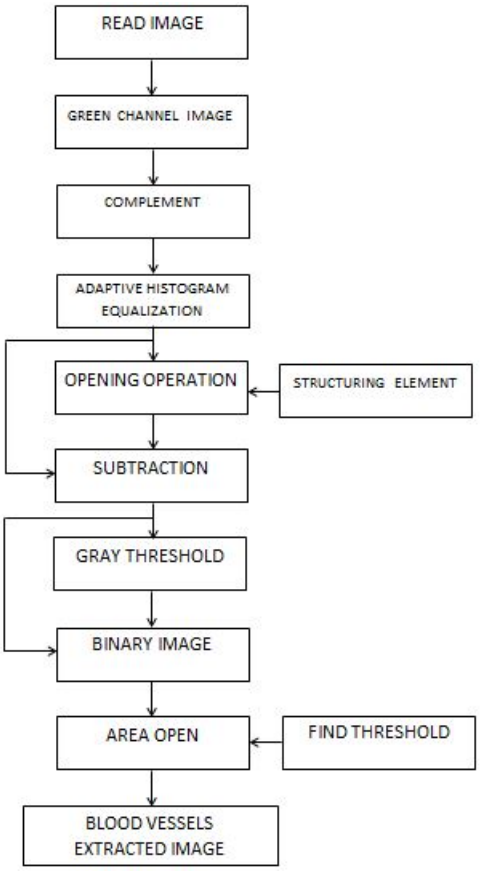

Figure 2: Blood Vessels Extraction

The fig 2 shows the algorithm that has been implemented in detecting the blood vessels.

The blood vessel detection is very essential in identifying diabetic retinopathy through image processing approach. The image acquired contains RGB color space. This is converted into a green channel image because the image appears more contrast in this space. Contrast limited adaptive histogram technique will normalize the image by removing high peaks in the image and redistribute those components back to the image. Morphological image processing technique is widely used in detection of blood vessel. Morphological operation is for smoothen the background and such that veins be seen clearly. After this morphological operation, the pixel intensity is spread more evenly over the entire image by adjusting the intensity image. Then the background of the processed image is not as noisy as the acquired original image and the veins can be distinguishably seen. The required area of the feature is obtained by thresholding the image. The background is made black and the extracted features as white. The area of the blood vessels is computed based on the extracted features that appear white in color.

B. Detection of Hard Exudates

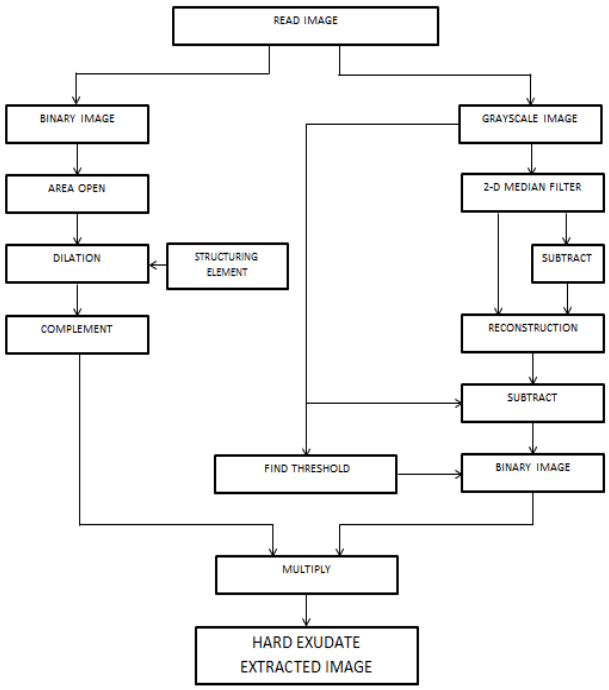

Figure 3: Hard Exudates Extraction

The input retinal images must be pre-processed before they are applied to segmentation process. The images that are not pre-processed will be blurred and normally have low contrast. Hence the problem of image blurredness and non-clarity must be rectified. It normally consists of color conversion and image enhancement. Several pre-processing technique are employed for automatic segmentation of hard exudates. In this process, the images are first converted into grayscale images. Pre-processing with grayscale conversion is more significant with color images and intensity adjustment should also be done on grayscale images. Green channel has high contrast between the bright and background retinal components as compared with red and blue. It is efficient to work on green channel of RGB space in order to localize optic disc and hard exudate.

The removal of optic disc has an essential role in retinal image analysis since it look like with similar color, intensity and contrast to the other features on the retinal images. The optic disc usually appears as a

bright yellowish in color and is specified by the largest high contrast among circular shape areas. To be distinguishably separable it must be applied with a dilation operation with a structuring element, which will eventually help in obtaining only optic disc. This is then complemented wherein optic disc appearing black in color, will be used later. The other side, the image is undergoing through a median filtering where a window slides over the image and the average of the neighbourhood of the sliding window is calculated and replaced with the centre pixel. The reconstruction operation is performed with the help of the marker image that is repeatedly dilated till it fits into the second image called the mask image. In this peaks in the marker image spreads out. Then using the gray threshold the image is converted to the binary image. In this binary image, optic disc and exudates appear as white. Finally the complemented image that has optic disc black in color is multiplied with the binary image that has optic disc in white color. Thus resulting image will have only the hard exudate with the removal of the optic disc

The area of the hard exudate is calculated based on the white pixels that are obtained.

C. Detection of Microaneurysms

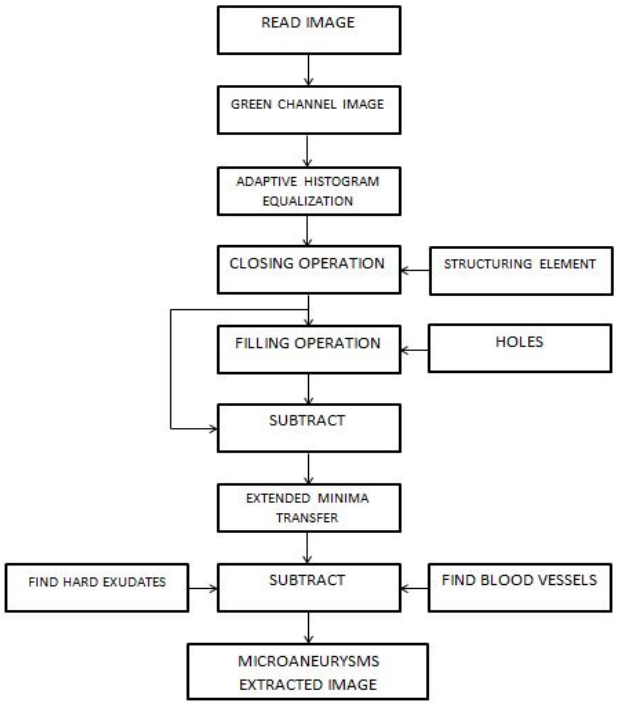

Figure 4: Microaneurysms Extraction

The microaneurysms are detected using morphological operations. The first step is the green channel since it provides high contrast as compared with red and blue. Adaptive histogram equalization is used for enhancing the image. Closing operation is applied for eliminating undesired details. Then the filling operator is used for filling the microaneurysms that appear as a set of background pixels that are not connected to the image border. Hence filling holes of a binary image consists of removing the background pixels that are not connected to the border of the image. Then the difference between the closed image and the filling image is found.

f_{diff}= close(f) – fill(f)

The difference image is binarized by thresholding. Then the extended minima transform is applied to the binary image. This is a way of thresholding technique where it suppresses all the minima intensity in an image with depth less than or equal to a pre-defined threshold that brings most of the valleys to zero. The external boundary pixels will have a high value. Then an inversion of extended minima transfer is applied where the external boundary becomes black and the extracted regions appear in white. The inversion is so done because the extracted feature of blood vessel and hard exudate appear white in color which are to be used for subtracting it from the image obtained from the inverted extended minima transfer.

Finally the blood vessel and hard exudates are removed from the microaneurysms.

$f_{MA}= f_{EMT} – f_V - f_{EX}$

RESULT

The below GUI depicts the automatic screening of Diabetic Retinopathy (DR) and provides corresponding treatment which enables the detection of the disease at ease.

The acquired retinal image is undergone through pre-processing and extraction wherein the features are extracted to examine whether the patient is affected by Diabetic Retinopathy (DR) or not. A suitable result can be obtained about the severity of the disease.

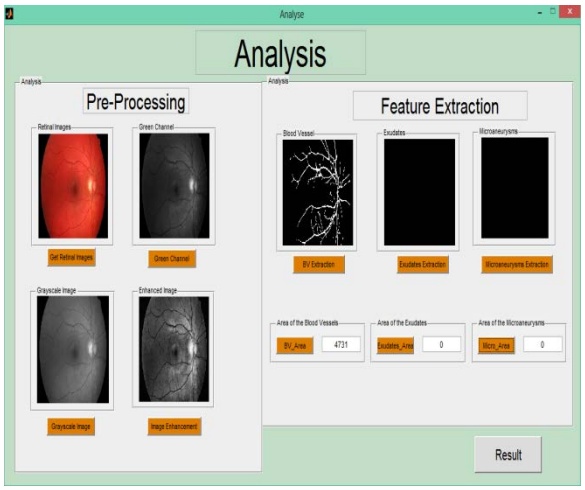

Figure 5: Pre-Processing and Extraction of unaffected DR

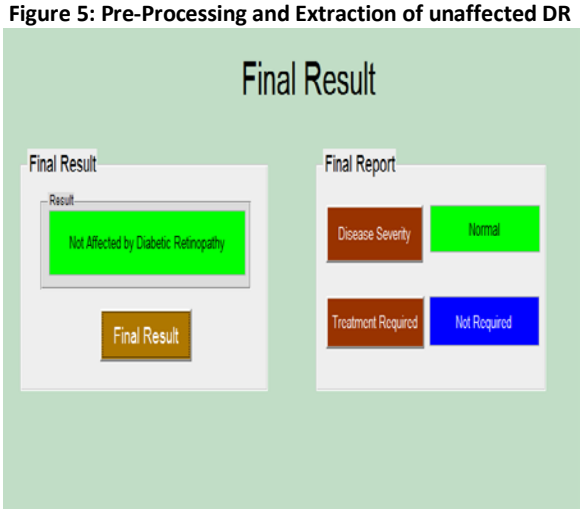

Figure 6: Disease Severity and Treatment required

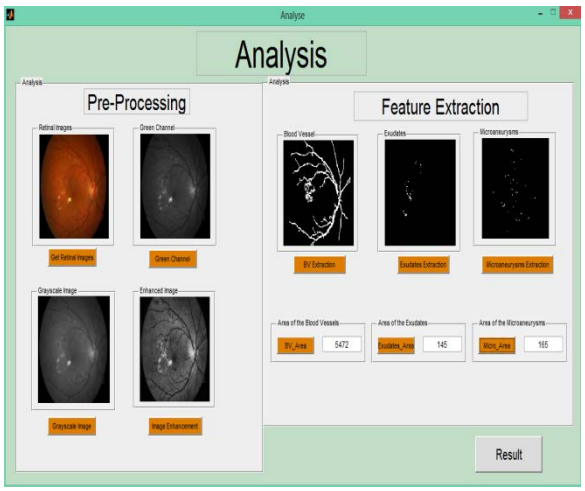

Figure 7: Pre-Processing and Extraction of affected DR

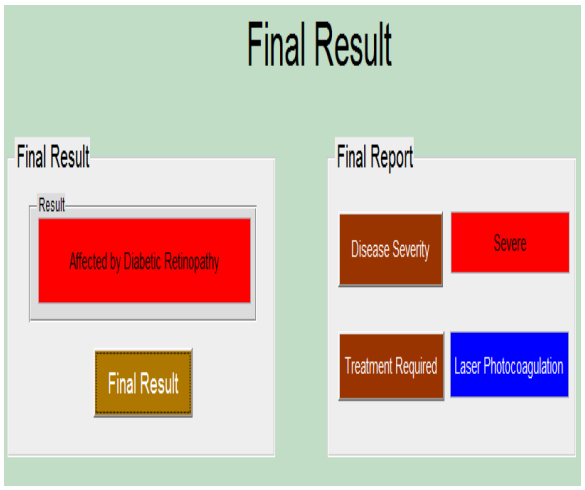

Figure 8: Disease Severity and Treatment required

According to the severity, the corresponding treatment is obtained. If there are no white pixels in the acquired retinal image, then there is no requirement for treatment. A certain threshold has been set for mild, moderate and severe of Diabetic Retinopathy. If the disease is mild then the corresponding treatment is Laser PRP. The moderate will result in vitrectomy treatment. Severe happens when the white pixels exceeds threshold of the extracted feature resulting in Laser Photocoagulation treatment.

CONCLUSION

A medical system for automatic diagnosis of Diabetic Retinopathy (DR) has been developed for automatic screening by using the effective image processing techniques. This system would provide the severity of DR with the corresponding treatment according to the severity. The results demonstrate that the system is well suited for screening of DR which helps the ophthalmologists in daily practice.

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