Automatic Detection of Diabetic Retinopathy- A Technological Breakthrough

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ABSTRACT
Diabetic Retinopathy is a dangerous eye disease and the most common cause of blindness for worldwide population. Digital color fundus images are becoming very important as they help in diagnosing Diabetic Retinopathy. With this fact new image processing techniques can be applied to improve automatic detection of diabetic retinopathy. Segmentation, feature extraction, enhancement, image classification, pattern matching are the major image processing elements in detecting eye diseases . Microaneurysms are the primary sign of DR, therefore necessary preprocessing step for a correct diagnosis to automatically detect the microaneurysms in fundus image is an algorithm. For detecting the microaneurysms in retina images this review paper aims to develop and test a new method.

General Terms
Detection, image processing, retina, vessels.

Keywords
MA, DR, NPDR, PDR, exudates, fundus, neovascularization, OCT.

1. INTRODUCTION
WHO projects that diabetes will be the 7th leading cause of death in 2030 and in 2014, 9% of adults 18 years and older had diabetes, also the global prevalence of diabetes was estimated to be 9% among adults aged 18+ years[1].Diabetic eye disease is a group of eye problems that people with diabetes face due to complication of diabetes. This can cause severe vision loss or even blindness[2].Below diagram shows the side view of an eye.

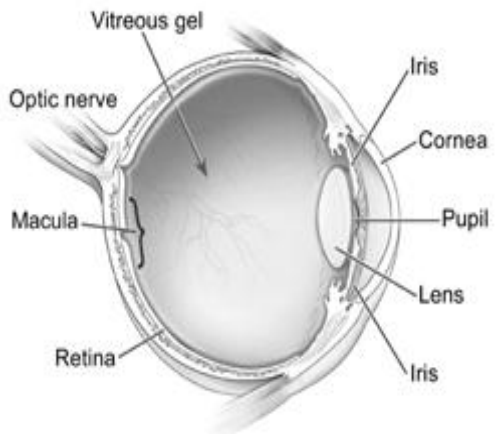

Fig 1: Side view of eye[2]

TYPE 1 DIABETES is also called insulin dependent diabetes which is usually diagnosed in childhood. when body makes little or no insulin then to sustain life daily injections of insulin are required.

TYPE 2 DIABETES this is more common than type 1 and is also known as non-insulin dependent diabetes, making 90% or more of all cases of diabetes. It usually occurs in adulthood. In patients suffering from type 2 diabetics pancreas does not make enough insulin to keep blood glucose levels normal as body does not respond to insulin. Many patients do not even know they suffer with type 2 diabetes, although it is a serious condition. Type2 diabetes is becoming more common due to increasing obesity, and not doing exercise.

GESTATIONAL DIABETES During pregnancy some women get this disease. In gestational diabetics high blood glucose develops in women who does not have diabetes[3].

The main diabetic eye diseases are:
1.Diabetic retinopathy-in which damage to the blood vessels in the retina occur.

2.Cataract-clouding of the eye's lens happens.

3.Glaucoma-optic nerve damage and loss of vision due to increase in fluid pressure inside the eye.

2. DIABETIC RETINOPATHY
DR is becoming a more important problem worldwide. Diabetic retinopathy (DR) is the most common cause of blindness in age group 20-74 years. It starts with mild nonproliferative abnormalities, characterized by escalated vascular permeability, and with the growth of new blood vessels on the retina and posterior surface of the vitreous progresses through moderate and severe nonproliferative diabetic retinopathy (NPDR) characterized by vascular closure, to proliferative diabetic retinopathy (PDR)[4]. According to survey around 60 million people in India are diabetic with youngster are more in number[5].Person having diabetics can prevent visual loss and blindness with diagnosis and treatment. However, worldwide more than 50% of patients suffering diabetics don't undergo any form of eye examination. The use of digital photography for examining retina by experts during screening programs appears to be both sensitive and exact in the detection of the early symptoms of diabetic retinopathy[6].DR is caused by changes in retina's blood vessels. Sometimes blood vessels may swell and leak fluid. otherwise normally, abnormal new blood vessels grow on the surface of the retina. The photosensitive tissue at the back of the eye is recognized as retina .For good vision a healthy retina is important[2].285 million people are estimated to be visually impaired worldwide: 39 million are blind and 246 have low vision[7]. During starting stage patients may not notice changes to their vision. But over time, usually affecting both eyes DR gets worse and cause vision loss .Diabetic retinopathy may also cause macular edema which happens when fluid leaks into the part of the retina that helps giving you the pointed, central vision you need for reading, driving, and seeing fine details. Otherwise,

things look blurry[8].DR is due to long-standing hyperglycemia, wherein retinal lesions (exudates and micro aneurysm and hemorrhages) appear that could lead to blindness. Below figure shows the comparison between normal retina and DR.

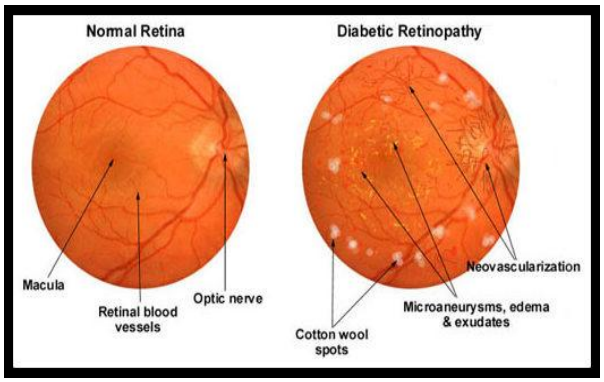

Fig 2: Comparison between normal retina and DR[9]

2.1 Stages of Diabetic Retinopathy

2.1.1. Mild Non-Proliferative Retinopathy

In this stages microaneurysms develop, MA is balloon-like swelling in the tiny blood vessels of the retina. MA is caused due to the distension of capillary walls.MA is the first clinical sign of retinopathy. MAs are less than 125 µm in size and appears as small circular reddish dots.

2.1.2 Moderate Non-Proliferative Retinopathy

Vessels supplying blood to the retina gets blocked.

2.1.3 Severe Non-Proliferative Retinopathy

Deprived areas of retina send signals to grow new blood vessels in order to maintain nourishment as many blood vessels are blocked. Consequently some areas of the retina do not get enough blood supply.

2.1.4 Proliferative Retinopathy

During this stage, the signals are sent by the retina for the growth of new blood vessels. New blood vessels formed are abnormal and fragile, prone to haemorrhage (blood leakage), that can lead to severe vision loss and even blindness[9].

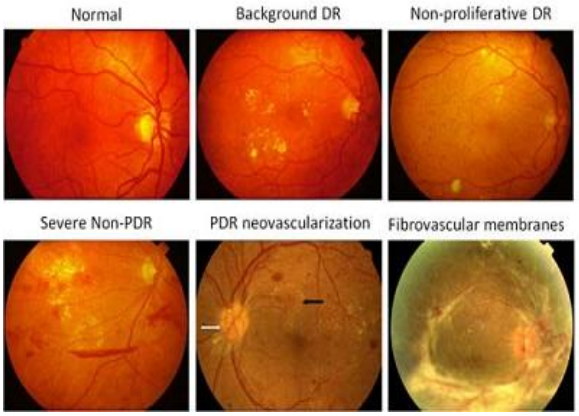

Fig 3: Diabetic retinopathy stages[10]

2.2 Diabetic Retinopathy Detection

Some of the Eye Exams performed on the diabetic patients are as follows:

2.2.1Visual Acuity Measurement

It measures the eye's ability to focus at different distances[11].

2.2.2 Ophthalmoscopy And Slit Lamp Exam

These tests allow doctor to view the back of the eye and structures including blood vessels, nerve bundles, and underlying layers within the eye. These can be used to detect clouding of the lens (cataract), changes in the retina, and other problems.

2.2.3 Optical Coherence Tomography

It is an imaging technique to get high-resolution images of the retina and the interior segment of the eye, to determine the thickness of the retina or the presence of swelling within the retina. This method is also being used by cardiologists seeking to develop methods to check for fluid in your retina [12,14,15].

2.2.4 Fundus Photography

Any process resulting in a 2-D image, where the image intensities illustrate the amount of a reflected quantity of light is known as fundus imaging and when for a specific waveband image intensities represent the amount of reflected light then it is called fundus photography. Fundus photography gives exact images of the back of the eye (the fundus). An eye doctor can compare images taken at different times to see the progression of the disease and look how well treatment is working[13,14].

2.2.5 Fundus Fluorescein Angiography

It is used to check for and locate any leaking blood vessels in the retina of diabetic patients showing symptoms that suggest damage to or swelling of the retina. can readily demonstrate the extent and location of capillary drop out [14].

2.3 Image Preprocessing Methods

Sometimes the retinal images obtained are of low quality and may contain artifacts because photographer does not have full control over patient's eye so image preprocessing methods are required. Also patients can't hold their eye still for a long time during image processing leading retinal images often unevenly illuminated with parts of the retinal image brighter or darker compared to the rest of the image, or can also be washed out with a little or complete loss of contrast[4].Following fig. shows the flow chart for the automated diagnosis of DR.

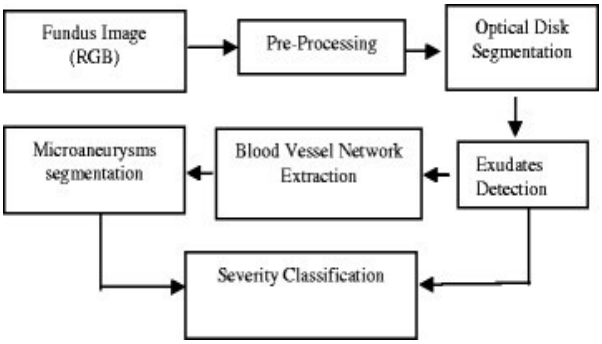

Fig 4: Flow chart for the automated diagnosis of DR using fundus image[15]

2.3.1 Detection of Retinal Vessel

Vessel detection can determine the severity of the disease and effect of the treatment so detection of retinal vessel is necessary and important too [16]. 2D matched filter based method to detect blood vessel is found to be more efficient than Sobel operator and morphological operator[17]. It is seen that with the help of genetic algorithm matched filter's sensitivity can be optimized [4].

Fig 5: Animated retinal blood vessel picture[18

2.3.2 Detection of Neovascularization

For the detection of the neovascularization studying blood vessel is very important. Neovascularization is proliferation of new blood vessels in the fundus area and inside the optical disk. So segmentation of blood vessel is important step to detect neovascularization[4].

2.3.3 Detection of Exudates

The primary sign of DR are exudates. To slow down the progression of retinopathy automatic detection is very important as exudates are the early lesions of diabetic retinopathy[4]. Malaya Nath et al. [19] proposed a novel method that due to development of diabetics by using independent component analysis (ICA) on wavelet sub bands changes appearing in the color fundus image can be detected. For the change detection the proposed method consists of steps such as splitting to different color channels, preprocessing, wavelet decomposition, selection of sub band, formation of input matrix for ICA, and fast ICA. The method for exudates detection proposed by Narsimhan et al. [20] involves three steps first, color histogram processing follows the localization of optic disc. detect the edges by segmenting. The segmentation is obtained by locating the edges in the smoothened input image. Third, for exudates detection color histogram thresholding is used. The computational intelligence technique and Fuzzy C-means clustering were used for the exudates detection[4].

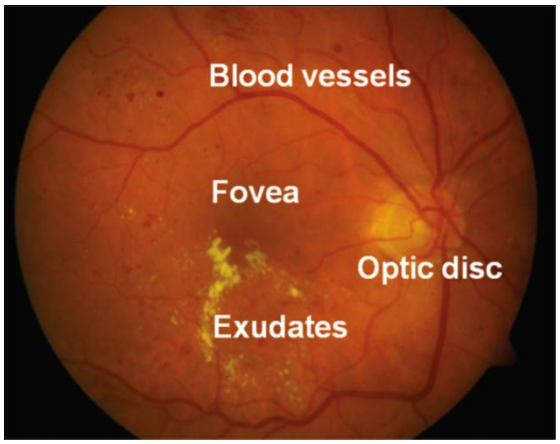

Fig 6: Retina showing exudates

2.2.4 Detection of Microaneurysm

Reliable automatic detection of microaneurysms is a major challenge. Some other challenges during detection of red lesion are segmentation of small MA in the areas of low image contrast and the presence of bright pathologies. To detect MA Narsimhan et al. [20] gave the method which involved morphological white top hat transformation to enhance and isolate the micro aneurysm. The difference between the input image and opened image gives the top-hat transformed image. For efficiently extracting the small circular structures from the image the structuring element is rotated in twelve different orientations.

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4. CONCLUSION

Here in this paper we have reviewed that new image processing techniques can be applied to improve automatic detection of DR. Computerized analysis of retinal images is an in progress active field of research. There are many diabetic patients yet not screened are under the danger of vision deprivation. We have seen that standard image processing techniques that may be found in any good text on general image processing can go a long way to detecting certain features/lesions in retinal images and produce seemingly good results. Determining of microaneurysms from the fundus image without the need of doing fundus fluorescence angiography is simple, flexible and robust.

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