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Extraction of Features from Fundus Images for Diabetes Detection

[1]S.J. Deshmukh, [2]S.B.Patil

[1, 2] Dept. E&TC, Sinhgad College of Engineering, Vadgaon, India

Abstract: **Diabetes is a quickly increasing worldwide problem which is produced by defective organic process of glucose secretion that produces long-term dis-function and harmful for different organs. The major problem of diabetes is diabetic retinopathy (DR), which are vascular diseases affecting the retina due to long time diabetes. It can produce sudden vision loss due to DR. So we need to develop the system to examine the retinal images for obtain important features of diabetic retinopathy by using the image processing techniques. First the entire image is segmented. From that segmented regions, we can check varying changes in blood vessels and different features for e.g. exudates, microaneurysms, and also a set of features such as color, size, edge and texture which can be used as part of an automatic diabetes recognition system.**

Keywords: **Fundus image, Diabetic retinopathy, features extraction.**

I. INTRODUCTION

Diabetic retinopathy is a micro-vascular complication of diabetes, causing abnormalities in the retinal image. Typically there are no detectable symptoms in the early stages, but the number and severity predominantly increase in time. In the following, the progress of the diseases described in detail. The diabetic retinopathy typically begins as small changes in the retinal capillaries. The smallest detectable abnormalities, microaneurysms (MA), appear as small red dots in the retina and are local distensions of the weakened retinal capillary Due to rupture and cause intra-retinal haemorrhages (HA). In the retinal image, the haemorrhages appear either as small red dots indistinguishable from microaneurysms or larger round-shaped blots with irregular outline

Diabetic retinopathy is regarded as a retinal vasculature disorder that evolves up to a degree in majority of the patients with diabetes mellitus [1]. Although diabetes itself cannot be prevented, but in many cases its blindness can be moderate and curable if the disease is diagnosed as early as possible.

The World Health Organization (WHO) has calculated that, the number of adults with diabetes in the world would increase tremendously: from 135 million in 1995 to 300 million in 2025[2]. In India, this increase is expected to be greatest, nearly 195% from 18 million in 1995.So we need to find something better which can our life better.

In this system for overall feature selection of retinal images by automatically detecting the blood vessels, exudates, hard exudates. The work is to develop an automated system to analyze the retinal image for extraction of features using image processing techniques. .Initially, it is pre-processed for color normalization and increasing the contrast of the image. The entire segmented images give a data set of regions.

II. BASIC CONSIDERATIONS OF EYE AND DIABETIC RETINOPATHY

A. Human eye:

The human eye is similar to the camera. The visual information is encoded and transmitted to the brain through the optic nerve.

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Light reflected from an object is focused on the retina after passing through the cornea, pupil and lens, which is similar to light passing through the camera optics to the film or a sensor. In the retina, the incoming information is received by the photoreceptor cells dedicated for light intensity. From the retina, the information is further carried out to the brain via the optic nerve, where the feeling of sight is produced. During the transmission, the information is processed in the retinal layers. There are three important features in the camera which can be seen analogous to the function of the eye i.e. aperture, camera lens, and the camera sensor. In the eye behind the lucid cornea, the colored iris determines the amount of light entering the eye by changing the size of the pupil. In the dark, the pupil is large allowing the maximum amount of light to enter, and in the bright the pupil is small keeping the eye to receive an excess amount of light. In the same way, the camera determines the amount of light entering the camera with the aperture. In order of the eye to concentrate on objects at different distances, the ciliary muscle remold the elastic lens through the zonular fibres. For objects in short distances, the ciliary muscle compacts, zonular fibres loosen, and the lens thickens into large shaped which results high refractive power. When the ciliary muscle is relaxed, the zonular fibres extend the lens into thin shaped and the distant objects are in focus. This equates to the function of focal length, i.e. the distance between the lens and sensor, when concentrating by the camera. If the eye is properly focused, the light passes through the vitreous gel to the camera sensor of the eye that is the retina.

In figure 1, cross section of the human eye is shown with the most important structure labeled.

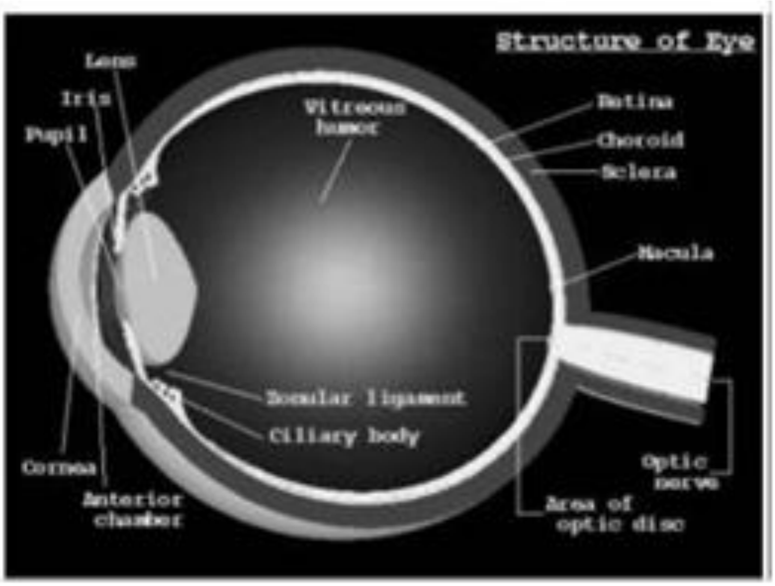

Fig.1 Cross-sectional view of Human eye

In this work, retina is the most important part of the eye. The specific vascular changes caused by diabetic retinopathy can often be detected visually by examining the retina [3].

B. Diabetic Retinopathy:

Diabetic Retinopathy (DR) is one of the most serious complications of diabetes and a major cause of visual morbidity. The risk of disease increases with age and therefore, middle aged and older diabetics are having more chances of DR. It causes no symptoms in its early stages, when it is most amenable to treatment. Automatic screening for DR has been shown to be very effective in preventing loss of sight.

Abnormalities associated with the eye can be divided into two main classes, the first being the disease of the eye, such as cataract, conjunctivitis, blepharitis and glaucoma [3].

The second group is categorized as life style related disease such as hypertension, arteriosclerosis and diabetes [4]. Ophthalmologist has come to agree that early detection and treatment is the best treatment for the disease [5]. A useful clinical symptoms detected on fundoscopy is as follows: (i) Microaneurysms (ii) Dot and blot hemorrhages (iii) Hard exudates (iv) Cotton wool spots and (v) Neovascularization

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The severity of diabetic retinopathy is divided into two stages: nonproliferative (background retinopathy) and proliferative retinopathy. The nonproliferative retinopathy indicates the presence of diabetic retinopathy in the eye and consist of microaneurysms, haemorrhages, exudates, retinal oedema, The microaneurysms and especially hard exudates typically appear in the central vision region (macula) which predicts the presence of macular swelling (macular oedema).

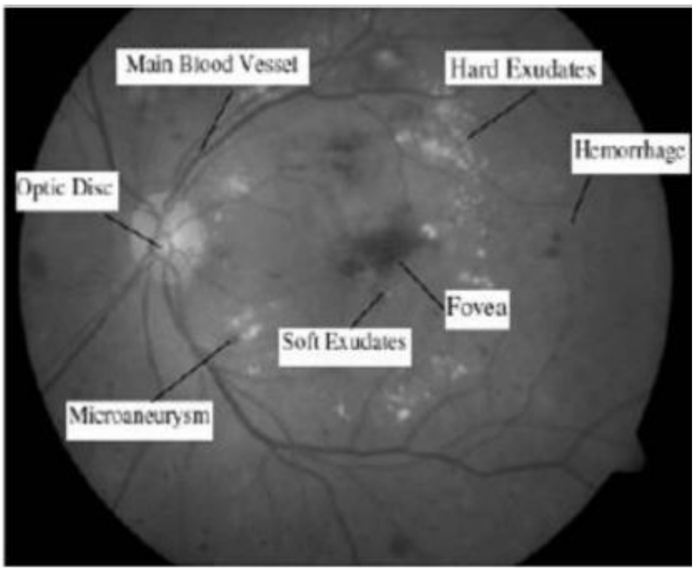

Fig.2 Illustration of various features on a typical Diabetic Retinopathy

III. COMPUTATIONAL METHODS FOR DR BASED DIABETES DETECTION

Here, we proposed a computational framework with the objective of automatic detection of diabetes from retinal images. The different constituents of the system are described below:

A. Morphological image processing:

Morphological image processing is a type of processing in which the spatial form or structure of objects within an image is modified. Mathematical morphology contains two fundamental operations: morphological dilation and erosion. Dilation expands and erosion shrinks objects marked in the image. Other morphological operations are for example morphological opening and closing which are based on dilation and erosion

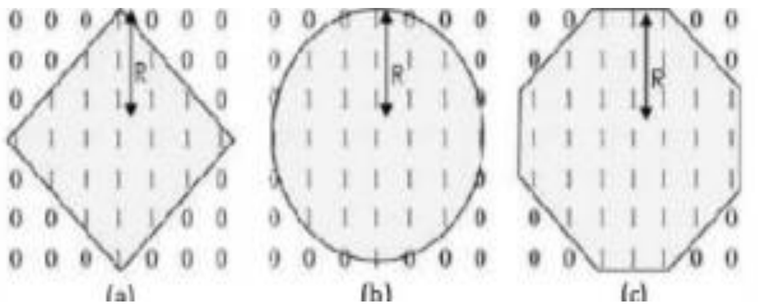

Fig.3 Structuring elements with R=3 (a) diamond (b) Disc (c) Octagon

An essential part of the dilation and erosion operations is the structuring element (SE) used to probe the input image. A structuring element is a matrix containing of only Os and Is that can have any arbitrary shape and size. Figure 3 shows diamond, disc and octagon shaped structuring element.

If f(x, y) is a finite -size grayscale image defined on grid Z2 and B is a binary structuring element [7], then,

Dilation:

(f (+) B) (x, y) =max {f(x - s, y - t)l (s, t) E B}. (1)

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Erosion:

(f8 B) (x, y) = min {f(x + s, y + t) l(s, t) E B}. (2)

Opening:

f o B= (f8B) (+) B. (3)

Closing:

f · B = (f (+) B) 8 B. (4)

B. Adaptive histogram equalization:

Adaptive histogram equalization is an image processing technique used to improve contrast in images. The main objective of this method is to define a point transformation within a local, fairly large window with the presumption that the intensity value within it is a stoical representation of local distribution of intensity value of the whole eye image [11]. The local window is assumed to be unaffected by the gradual variation of intensity between the eye image centers and edges. The point transformation distribution is localized around the mean intensity of the window and it covers the entire intensity range of the image. Consider a running sub image W of N X N pixels centered on a pixel P(ij).

The image is filtered to produce another sub image P of (N X N) pixels according to the expression:

$$P_n = 255\left(\frac{[\varnothing w(p)-\varnothing w(min)]}{[\varnothing w(max)-\varnothing w(min)]}\right) \quad (5)$$

$$\phi\omega(\mathrm{P}) = \left[1 + exp\left(\frac{\mu_\omega - \mathrm{P}}{\sigma_\omega}\right)\right]^{-1} \quad (6)$$

Max and Min are the maximum and minimum intensity values in the, whole eye image while μ_ω indicate the local window mean and $\sigma_\omega$indicate standard deviation which are defined as

$$\mu_\omega = \frac{1}{N^2} \sum_{(i,j)\in(k,l)} \mathrm{P}(i,j) \quad (7)$$

$$\sigma_\omega = \sqrt{\frac{1}{N^2} \sum_{(i,j)\in(k,l)} (\mathrm{P(i,j)} - \mu_\omega)^2} \quad (8)$$

IV. FEATURE EXTRACTION METHOD

Here, we proposed a set of features formulated for the automated diabetes recognition system. The feature set captures nearly all essential attributes of the retinal image necessary for appropriate decision making.

Detection of Exudates:

DR is the most common cause of blindness in the working population of the United States. Early diagnosis and timely treatment have been shown to prevent visual loss and blindness in patients with diabetes. For patients recently diagnosed with diabetes a high proportion of normal appearing fundi are expected and only 5%-20% may demonstrate fundoscopically visible diabetic retinopathy. Digital photography of the retina examined by expert readers has been shown to be sensitive and specific in detecting the early signs of retinopathy. Early diabetic retinopathy lesions may be classified into 'red lesions', e.g. microaneurysms, hemorrhages and intra-retinal micro vascular abnormalities, and "bright lesions", such as lipid or lipoprotein exudates and superficial retinal infarcts (cotton wool spots)

Applying a green component to the histogram equalization and a grayscale closing operator (<p) on the histogram image 1 will help eliminate the vessels which may remain in the optic disc region.

12 = ϕ (B 1) (I) (9)

Where 'B1' is the morphological structuring element. The resulting image 12 is binarized by thresholding (a1). After, we remove from the binary image all connected components that have fewer than P pixels, producing another binary image; P is chosen such that it is smaller than the maximum size of the optic disc center in the fundus image.

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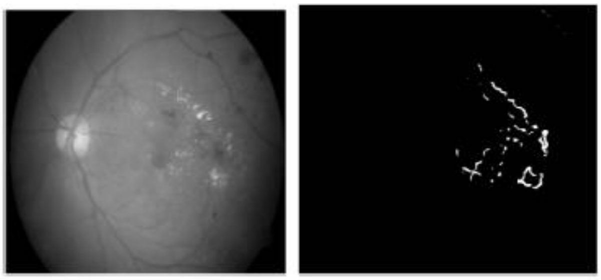

Fig.4 Fundus image (left) with its exudates (right)

Detection of hard and cotton wool spots:

The exudates are detected based on the color histogram thresholding. For this, initially we split the color fundus image into number of non-overlapping blocks. Then, calculate color histogram for each block of the image. By the use of threshold value based on color histogram, exudates are detected over the color fundus image. The threshold is chosen in a very tolerant manner, i.e., to differentiate the hard and soft exudates region in a color fundus image. Finally based on the chosen threshold value, the soft and hard exudates are detected from the color fundus retinal image [10].

Fig.5 Fundus Image with Extraction of Hard Exudates

Detection of vascular tree:

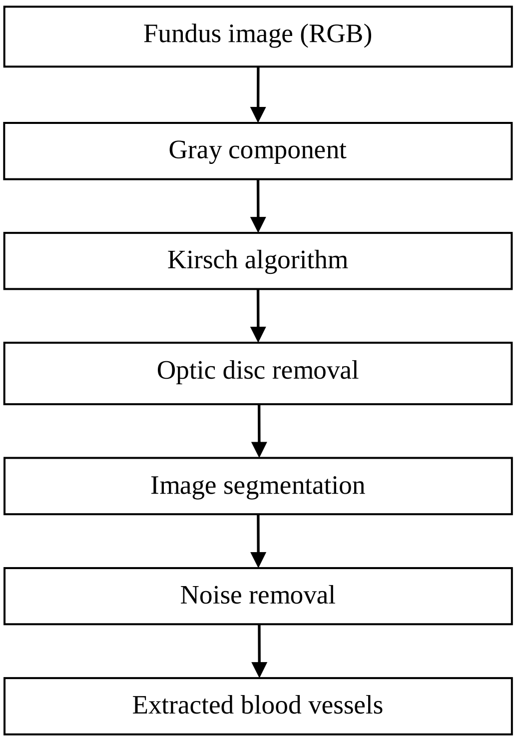

Fig.6 Block diagram of vessel extraction

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The extraction is related to the green channel of the RGB color space, because blood containing features appear most contrasted in this channel. The algorithm used is Kirsch's algorithm and classical matched filter. The Kirsch operator has a number of templates where each template focuses on the edge strength in one direction. The kirsch algorithm cycles for each 45°, through the desired number of directions and assigns an attribute for the best direction. The best direction is the corresponding to the largest edge strength (gradient magnitude) [9]. In this method, a single mask is taken and rotated to 8 major compass orientations:

N, NW, W, SW, S, SE, E and NE. The mask that produces the maximum magnitude gives the edge direction. One is edge detection; the other is tracking which needs a priori knowledge of the beginning position in the image. The former method is applied in this project. It computes the gradient by convolution the image with eight template impulse response arrays (HI to Hg). The scale factor is1/15.The optic disc is removed with the circular mask after which the white noise is removed using the morphological opening and closing.

5	-3	-3
5	0	-3
5	-3	-3

H_1 East

-3	-3	5
-3	0	5
-3	-3	5

H_2 West

-3	-3	-3
5	0	-3
5	5	-3

H_3 Northeast

-3	5	5
-3	0	5
-3	-3	-3

H_4 Southeast

-3	-3	-3
-3	0	-3
5	5	5

H_5 North

5	5	5
-3	0	-3
-3	-3	-3

H_6 South

-3	-3	-3
-3	0	5
-3	5	5

H_7 Northwest

5	5	-3
5	0	-3
-3	-3	-3

H_8 Southeast

Fig.7 Impulse response arrays of Kirsch's method

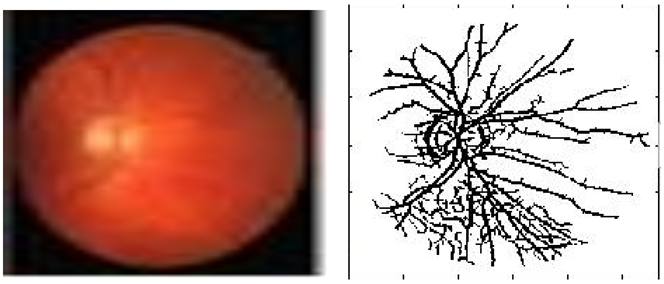

Fig.8 Fundus Image with blood Vessels

V. CONCLUSIONS

Here, in this method we have described a process of extracting Exudate and optic disc feature for use with a proposed automated diabetes recognition system.

This feature is used for critical application which shall be crucial for diabetes detection and related disorders.

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