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AUTOMATED DETECTION AND SEVERITY ESTIMATE OF DIABETIC RETINOPATHY

Pragati Sharma
Dept. of Computer Science and Engineering
R.B.S Engineering Technical Campus,
Agra

Dr. B.D.K Patro
Dept. of Computer Science and Engineering
R.B.S Engineering Technical Campus,
Agra

ABSTRACT: There is an aggregating interest in development of the automatic medical diagnosis systems because of the elevation in the computer technology. The knowledge regarding health and disease is required at higher rate for the precise medical diagnosis. Diabetic retinopathy is the common cause of blindness. Diabetic retinopathy is a medical condition where the retina is damaged because fluid leaks from blood vessels into the retina. Exudates are one of the prior signs of diabetic retinopathy, which is a main cause of blindness and can be avert with an early screening process. In this paper, authors have attempted to detect exudates using back propagation neural network. Exudates detection is important for diabetic retinopathy screening systems. Early detection can help to reduce the incidence of blindness in diabetic patients. This paper presents a computer aided system which can be used for detection and the severity estimate of the diabetic retinopathy. This paper presents various algorithms on fundus retinal images by following steps like preprocessing, lesion detection, features extraction using fuzzy logic and using neural network.

KEYWORDS: Diabetic retinopathy, image preprocessing, back propagation neural network, exudates, HSI color space, features extraction.

1. INTRODUCTION

Eyes are the most complex and delicate organ of our human system, despite being small in size of two centimeters in diameter, human eye system have over 2 million moving parts. The eye works like a camera, it focuses images through a series of lenses, and our eyes allow us to see the world around us. Human eyes may be highly advanced, but they are still susceptible to a number of problems. One of the severe problems that can lead to human vision loss is diabetic retinopathy usually seen in diabetic patients. Diabetic Retinopathy (DR) is becoming the most common problem these days. Patients suffering from diabetes usually have the retinal problems like hair growth in retina, retinal detachments etc. Detection of Diabetic Retinopathy (DR) is highly required and the severity check of the problem is also an essential part to detect in the Diabetic Retinopathy, as the high diabetic retinopathy may lead to severe damages in the eye or even it may lead to loss of vision. Eye specialists may look for the following signs when diagnosing diabetic retinopathy in their patients: micro aneurysms, intra retinal vascular abnormalities, swelling and beading of venous system, or hard and soft exudates.

- ***Diabetes:*** "Diabetes" is also acknowledged as the "diabetes mellitus", which is a collection of metabolic ailments in which the patient undergoes from "high blood glucose" i.e. "blood sugar," it may be for the reason that insulin produced is insufficient, or because of the body cells which do not reply properly to insulin, or both of the reasons. Diabetes is a serious complex condition which can affect the entire body. Diabetes requires daily self-care and if complications develop, diabetes can have a significant impact on quality of life and can reduce life expectancy. While there is currently no cure for diabetes, you can live an enjoyable life by learning about the condition and effectively managing it.
- ***Retina:*** "Retina" is the lightest sensitive and delicate layer at the back of the eye. It covers around 65 percent of the internal surface of the eye. It is the innermost and very significant layer in the eye. It consists of various substantial material patterns which can help in representing numerous diseases.
- ***Lesions:*** "Lesions" are the formation of spots on the retina or at the back of the eye of the patient. These lesions can be formed due any kind of leakage from the new blood vessels, any unwanted growth of particles, "pale-fatty deposits" on the retina, "retinal swelling", nerve tissues that get damaged

(neuropathy), or any changes in the blood vessels. There are two kinds of lesions knows as bright lesions and dark lesions.

a. Bright Lesion: Bright lesions are the light intensity spots which may be white or yellow in color with the irregular shape structure of lesions. They are of two kinds "exudates and cotton wools."

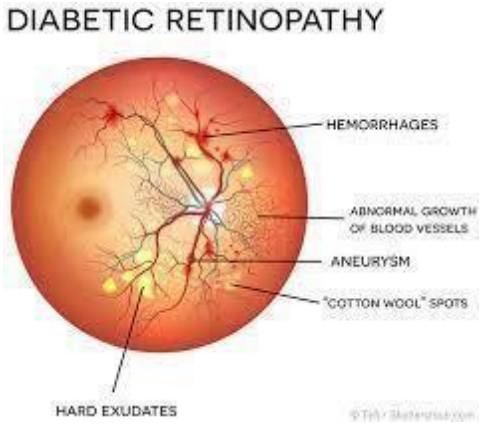
- ***Exudates:*** An unsolidified or watery material with rich protein and cellular components that hail from the blood vessels because of redness and it is usually placed in neighboring tissues of the blood vessels[1]. "Exudates" lie near the blood vessels with irregular shape. They are yellowish in color with sharp edges. Sizes of exudates vary from small to very large.
- ***Cotton Wools:*** These are white spots with oval shaped structure. They are designed by retinal nerve fiber layer micro infarcts. Scattered "retinal ganglion cell axons" oozes "axoplasm" like paste[1]. Expected to find the presences of cotton wool spots around the optic disc and along the progressive vascular arcades.

b. Dark Lesion: Dark lesions are the dark intensity spots which are dark reddish in color with the round or dot flamed structure of lesions having clear and blur images. They are of two kinds "micro aneurysms and hemorrhages."

- ***Microaneurysms:*** A retinal "micro aneurysm" is a very minor zone of blood bulging from any artery or a vein at the back of the eye[3]. These budges usually open out and leaks the blood into the retinal nerve adjoining it. "Microaneurysms" are dark red in color with a very small in size and round in shape.
- ***Hemorrhages:*** A "hemorrhage" is an abnormal bleeding in the blood vessels the liquid that comes out of the blood vessels is the outflow of lipids from the blood vessels. The 17 "hemorrhages" are usually found on the blood vessels in the eye. The size of the "hemorrhages" vary from small to large[3]. They are dark red in color with the dot flamed edge.

- **SYMPTOMS OF DIABETIC RETINOPATHY**

Fluctuating or changing Vision: This is often one of the first symptoms of diabetes and although it can be very annoying, it is not dangerous to your eyesight. It is caused when the high blood sugar levels lead to a swelling of the natural lens in the eye, which then results in a change of focus or refractive power of the eye. A change in the refractive power feels like you need new glasses but as soon as your blood sugar levels go back to normal your focus changes again and you will find that you can see with your old glasses.



CAUSES OF DIABETIC RETINOPATHY

- Type I Diabetes (Juvenile Diabetes) develops when the pancreas produces too little insulin. This condition generally starts in childhood.
- Type II Diabetes (Adult-Onset Diabetes) develop over many years, and is caused by the pancreas either not producing enough insulin or not being able to utilize the insulin produced effectively.
- Low insulin sensitivity: enough insulin is present, but the physiology doesn't respond adequately.
- Poor diet high in refined carbohydrates and sugar, low in whole foods and antioxidants.
- Lack of regular exercise.
- Depression has been tied to an increased risk of developing diabetes.

1.1 STARE DATABASE

The standard available dataset of diabetic retinopathy, namely "STARE (Structured Analysis of the Retina)" [5] has been used in this project. "STARE" contains 71 images of resolution 605*700*3 with 58 images containing exudates and cotton wools while the remaining 13 images are normal.

The STARE (Structured Analysis of the Retina) Project was conceived and initiated in 1975 by Michael Gold Baum, M.D., at the University of California, San Diego[5]. It was funded by the U.S. National Institutes of Health .During its history, over thirty people contributed to the project, with backgrounds ranging from medicine to science to engineering. Images and clinical data were provided by the Shiley Eye Center at the University of California, San Diego, and by the Veterans Administration Medical Center in San Diego.

2 MATERIAL AND METHODS

2.1 BACKGROUND AND RELATED WORK

Preprocessing is done to extract retinal image from background and to enhance its quality by removing noisy areas. In automatic diagnosis of diabetic retinopathy, the processing of the surrounding background and noisy areas in retinal image is not necessary and consumes more processing time at all stages. Cutting or cropping out the region that contains the retinal image feature minimizes the number of operations on the retinal image. Noise in color retinal image is normally due to noise pixels and pixels whose color is distorted. Both seem to exist in regions where illumination has been inadequate. Since illumination is usually adequate in the center of the image, poor image quality regions are located near the edge of the retinal image. Regions with poor image quality may cause errors in abnormality detection. That is why they should be detected and removed before detection of abnormalities.

2.2 OVERVIEW

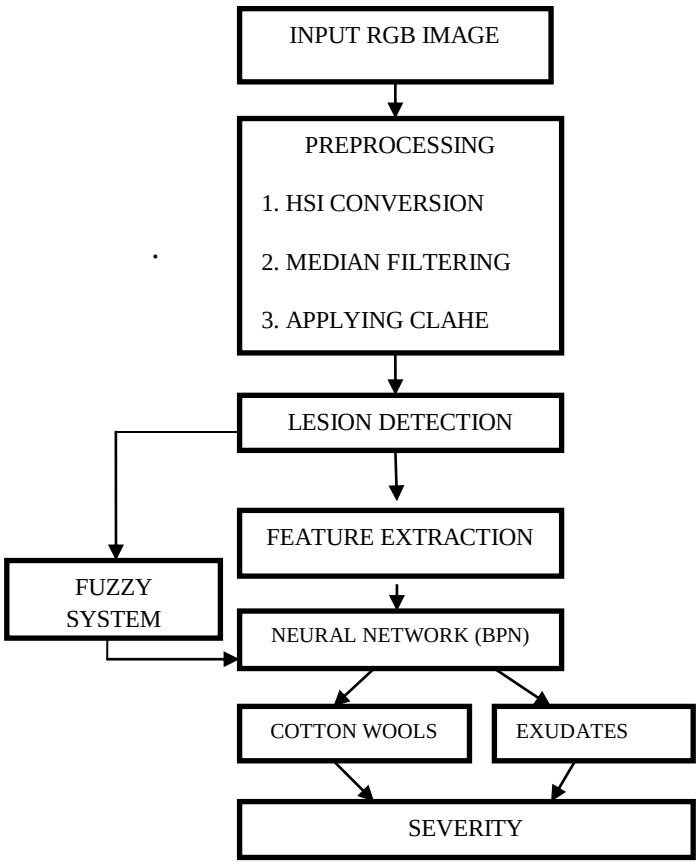
Computer assisted diagnosis for various diseases is very common now a days and medical imaging is playing a vital role in such computer assisted diagnosis. Image processing techniques can help in detecting dark and a bright lesion from retinal image for diagnosis of DR. NPDR, also known as background DR, includes early sign of DR and can be diagnosed if detected accurately and in time. The proposed Digital Diabetic Retinopathy System (DDRS) uses a three stage procedure. In first stage preprocessing is done to remove the background and noisy are from input retinal image. The blood vessel enhancement and segmentation followed by OD localization and detection is performed at second stage. In third stage, a hybrid fuzzy based classifier is used for detection of dark and bright lesions. DDRS uses blood vessel segmentation and OD for accurate detection and segmentation of different lesion for early detection and treatment of DR. Then apply neural network. Neural Networks is the backbone of this problem. Applied supervised learning (Back propagation Algorithm) to detect the problem. Then used the features to detect the severity of the problem.

2.3 PROPOSED METHODOLOGY

In this paper we have described, the automation for detecting the severity in a fundus image of an eye with a problem of diabetic retinopathy. Manual detection of different problems in "diabetic retinopathy" is

time consuming and gives less accurate results. This paper proposes an automatic detection of "Diabetic Retinopathy ", which is helpful for ophthalmologists. It detects the bright lesions in the eye which are the problems of "diabetic retinopathy" like "cotton wools and exudates. The presence of DR can be detected by its different signs; the most distinctive is the presence of cotton wool and hard exudates which are bright lesions. It is necessary to localize the presence of optic disk and the structure of blood vessels. They play a very important role in the accurate detection and classification of hard exudates. Detection of Diabetic retinopathy is very necessary to avoid blindness or vision impairment.

Flow chart for Automated Detection of Diabetic retinopathy and its severity:



2.3.1 PREPROCESSING

Image pre-processing is fundamentally required to eliminate the occurrence of noise in the image and equalization of the unbalanced illumination present inside the fundus retinal images .The image preprocessing includes the following steps:

a. ***HSI Colour Space Conversion:*** Colour is the brains reaction to a specific visual stimulus. Although we can precisely describe colour by measuring its spectral power distribution (the intensity of the visible electromagnetic radiation at many discrete wavelengths) this leads to a large degree of redundancy. The reason for this redundancy is that the eye's retina samples colour using only three broad bands, roughly corresponding to red, green and blue light.

b. ***Median Filtering:*** Median filtering is the best technique for suppressing the secluded noise without distorting sharp edges. It modifies the pixel by the degree of median of all pixels in the surrounding of small sliding window. Median filter helps in eradicating the salt and pepper noise and horizontal perusing artifacts. During the image pre-processing, the salt and pepper noise is added to the intensity band and then it is strained by using median filtering of 3*3 size

c. ***Adaptive Histogram Equalization*:** The fundus images typically consists of the rough illumination, the central zone of the image is the brightest part of the image as related to the lateral areas of the image.

Hence the brightness of the image reduces as we move away from the center of the image. To get even illumination, "contrast limited adaptive histogram equalization" is used. With the help of this the darker area of the input image turns out to be the brighter area in the output image[8]. It keeps the uniform illumination in the image. Adaptive histogram equalization (AHE) is a computer image processing technique used to improve contrast in images. It is therefore suitable for improving the local contrast and enhancing the definitions of edges in each region of an image.

2.3.2 DETECTION OF LESIONS

Lesions are formed by the leakage of blood vessels. Different lesions have different intensity values of pixel. To identify the lesions, intensity value of pixels is calculated using a dynamic thresholding technique. Manually the threshold value of lesions is calculated for 50 images in database. On the basis of observation of manual thresholding a general mathematical equation is formed to calculate a general threshold value for each image as follows:

K = ((min (M) + max (M)) / 2) + (max (M) / 4)

M = Intensity value of pixel

min (M) = minimum intensity value of pixel

max (M) = maximum intensity value of pixel

If the intensity value of the pixel in the image is less then the threshold value calculated from the general equation, then new value for that pixel value is zero whereas if the intensity value of the pixel in the image is greater then the threshold value calculated from the general equation, then the new pixel value is one. The resultant image will consist of the lesions in the image.

2.3.3 FEATURE EXTRACTION

a. Geometric Features such as Area, Perimeter, Compactness.

- ***AREA:*** Area is the total number of pixels in a particular lesion in a given image.
- ***PERIMETER:*** Perimeter can be defined as the total number of pixels at the boundary of the lesion.
- ***COMPACTNESS:*** The feature compactness defines that how closely or compactly the total number of pixels in a lesion are attached or joins.

b. Hue Features: "The pure color of a lesion is described by a color attribute known as hue" [2]. Average hue and Standard deviation of a hue helps in determining the color of a lesion.

c. Saturation Features: "Saturation gives a measure of the degree which the amount of white light mixed with the hue"[4]. Average saturation and Standard deviation of a saturation helps in determining the color of a lesion.

d. Intensity Features: "The lightness, intensity or value is related to the color luminance"[2]. Average intensity and Standard deviation of a intensity helps in determining the color of an lesion.

2.3.4 FUZZY SYSTEM

A fuzzy system consists of the fuzzy rules which are formed on the basis of two components size and color. On the basis of these fuzzy rules classification is followed for exudates and cotton wools.[6]

a. Size: Size describes the variation in structure of lesions on the basis of their sizes in a trapezoidal function

b. Colour: Color describes the shade of lesions. Color helps in classifying the type of a lesion on the basis of their colour in a Gaussian function.

2.3.5 BACK PROPAGATION ALGORITHM

Back propagation is a supervised learning algorithm, every input in a back propagation algorithm requires a desired output so that loss function gradient can be calculated. It maps the set of inputs to the correct outputs.

Back propagation learning algorithm is divided into two sub modules.

Module 1 Propagation: For each propagation has the following steps:

"Forward propagation of a training pattern's input through the neural network in order to generate the propagation's output activations" [7].

"Backward propagation of the propagation's output activations through the neural network using the training pattern target in order to generate the deltas of all output and hidden neurons"[7]

Module 2 Weight Update: For each weight-synapse has the following steps:

1) "Multiply its output delta and input activation to get the gradient of the weight."[7]
2) "Subtract a ratio (percentage) of the gradient from the weight."[7]

2.3.6 SEVERITY ESTIMATION

Severity in Diabetic Retinopathy has four levels.

- Level one describes the most severely affected eye with the disease which may lead to blindness. If the area of a lesion is large and color is yellow it shows that the severity of diabetic retinopathy is high.
- Level two describes the less affected eye with the disease which may lead to severe problems for the loss of vision. If the area of a lesion is small and color is yellow it shows that the severity of diabetic retinopathy is less high.
- Level three describes the less affected eye with the disease which may lead to severe problems for the loss of vision. If the area of a lesion is large and color is white it shows that the severity of diabetic retinopathy is low.
- Level four describes the most severely affected eye with the disease which may lead to blindness. If the area of a lesion is small and color is white it shows that the severity of diabetic retinopathy is very low.

3. RESULTS

3.1 *Preprocessing*

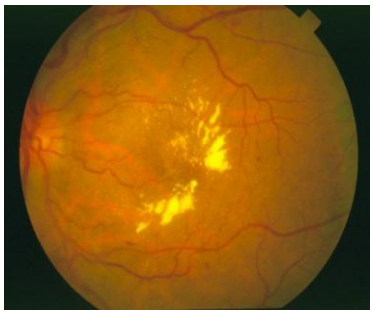


Fig 1 Original RGB Image

3.1.1 Image after converting RGB image into hue, saturation, intensity image.

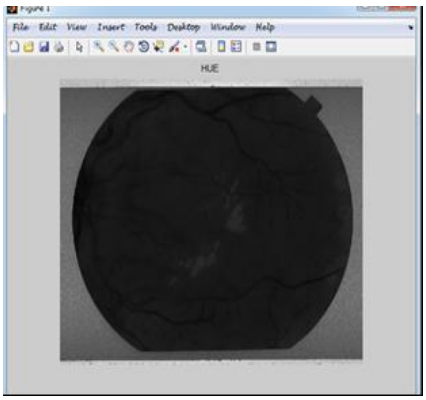


Fig 2 HUE Image

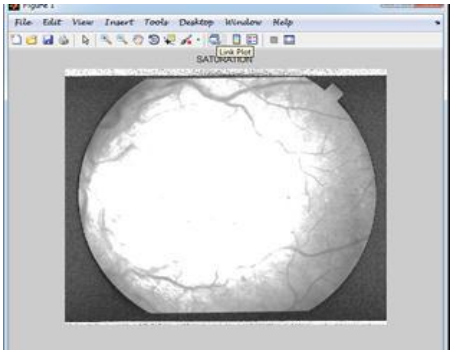


Fig 3 SATURATION Image

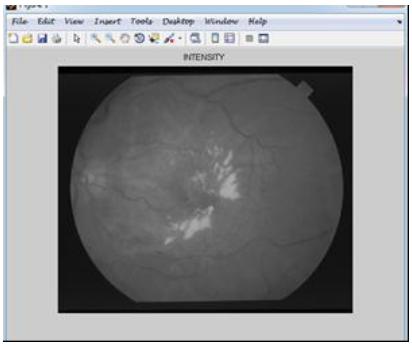


Fig 4 INTENSITY Image

3.1.2 Image after applying Median Filtering.

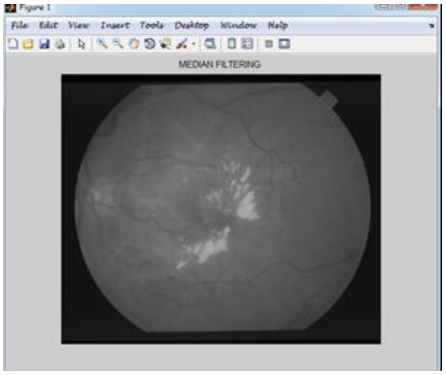


Fig 5 MEDIAN FILTER

Fig 6 CLAHE

4. CONCLUSION

In this paper an automatic detection of "Diabetic Retinopathy ", which is helpful for ophthalmologists. It detects the bright lesions in the eye which are the problems of "diabetic retinopathy" like "cotton wools and exudates." Early detection and timely treatment of DR can slow down the progression of the disease and prevent blindness.

5. FUTURE ASPECT

"Diabetic Retinopathy" consists of four problems "exudates, cotton wools, microaneurysms and hemorrhages." We can have a new approach by detecting the dark lesions in the eye that are "microaneurysms and hemorrhages." Both the bright lesions and the dark lesions together can help in increasing the accuracy of the detection of the "diabetic retinopathy." As well we can determine the stages of "diabetic retinopathy" after detecting the dark lesions.

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