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Robust Automated System for Detection of Exudates in Diabetic Retinopathy and Theoretic Approach to Detect the Retinal Detachment

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1. ABSTRACT:
It has been noticed that there is a significant and aggregating interest in the development of the automated medical diagnosis systems because of the greater advancement in present computer technology. Diabetic Retinopathy is a common cause of visual impartment or extreme visual disorders among people of working age in various industrialized countries. It can lead to blindness. This paper presents the automated detection of diabetic retinopathy and its factors from retinal images using various image processing techniques. The process begins with blood vessel detection and optic disk elimination because these it is one of the main important feature that help the ophthalmologists to detect the disease faster and easier. I propose a computer aided system which can be used for detection of exudates. The project presents various algorithms for fundus retinal images pre-processing, blood vessel detection and optic disk localization and detection of exudates. The developed method is tested on two different publically available databases and the comparison of the performance metrics is performed over it.

Keywords:
Diabetic retinopathy, Fundus images, automated detection, Blood vessel area, Exudates, Haemorrhages, Optic Disk.

2. INTRODUCTION:
Eyes are one of the most complex and delicate organ of our human system. Despite of being so small in size of two centimetres in diameter, human eye system has over 2 million parts as moving segment.

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. If the problem grows, severe non proliferative diabetic retinopathy enters into an advanced or proliferative (PDR) stage when blood vessels proliferate and proper oxygen is not supplied to retina causing fragility and retinal detachment. On time treatment is highly to be considered, else these new blood vessels can bleed, cloud vision, and destroy the retina. Eye specialists may look for the following signs when diagnosing diabetic retinopathy in their patients: microaneurysms, vascular abnormalities, swelling and beading of venous system.

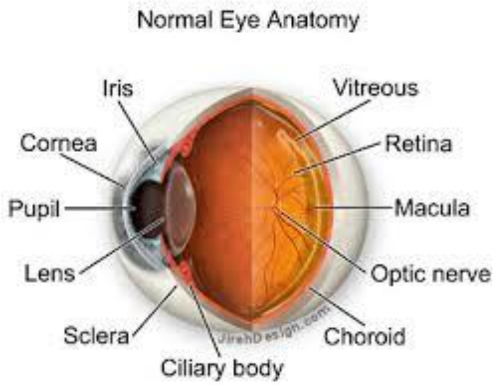

Fig1. Normal Eye Anatomy

3. METHODOLOGY:
The publically available datasets of diabetic retinopathy STARE [1] and Ex_optha[2] has been used in this detection methodology. STARE contains 402 images of resolution 605*700*3 with nearly 330

images containing exudates while the remaining 72 images either contains different type of lesions or are normal. Ex_optha consist of 100 images out of which nearly 30 images are healthy images and 70 images consist of exudates in it.25 images of Ex_optha out of which I have used 4 normal images and 23 images consisting of exudates.

3.1 IMAGE PREPROCESSING:

There is a vast difference in contrast, brightness and luminosity inside the retinal images, which make it complex and extort retinal features. Therefore, image pre-processing is required to eradicate the presence of noise in the image and equalization of the irregular illumination associated with fundus retinal images .The image pre-processing includes the following steps and are explained in detail subsequently.

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1. HSI Colour Space Conversion.
2. Median Filtering
3. Adaptive Histogram Equalisation

3.1.1 HSI COLOR SPACE CONVERSION:

An RGB image is M*N*3 array of colour pixels, where each pixel is the colour of triplet which corresponds to red, green and blue; they are the component of RGB image at specific locations. The original RGB image is converted to HSI (HUE, SATURATION and INTENSITY) colour space[3]. The HSI is the most common colour space that is used for image pre-processing applications because it shows the exact colour similarity as the human eye senses the colour. The foremost reason of using HSI colour space is that the intensity matrix can be differentiated or separated from the other components of the colour model like hue and saturation, so that the important information required for detection of exudates, which is contained in the intensity matrix only can be extracted like intensity, standard deviation of intensity, mean pixel value and exudates and non exudates can be extracted. HUE is a colour attribute that describes a pure colour whereas saturation gives a measure of the degree which the amount of white light mixed with the hue. The "lightness", "intensity" or "value" is related to the colour luminance.[4]

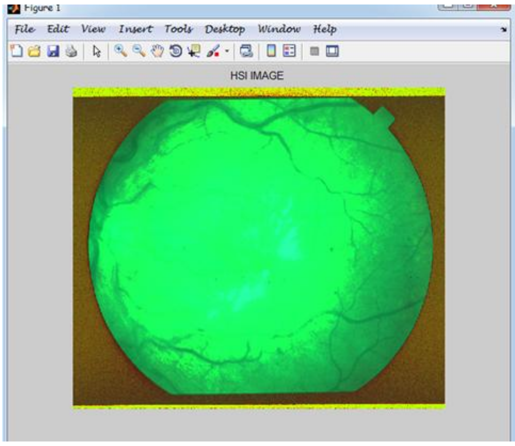

FIG 3.1.1 (a) HSI IMAGE

The equations used for the transformation of RGB to HSI are:

Hue component is given by:

$$H = \theta \ (if\ B \leq G)$$

Else

$$360 - \theta \ if\ B > G$$

Where $\theta = \cos^{-1}\{½$ $[(R-G) + (R+B)] / [(R-G)^{2} + (R-B)\ G-B)^{2}]^{1/2}\}$

This equation helps for the transformation of RGB to HSI .Beginning with Hue denoted by H in the above mentioned equation. The figure 3.1.1 b shows the HUE image.

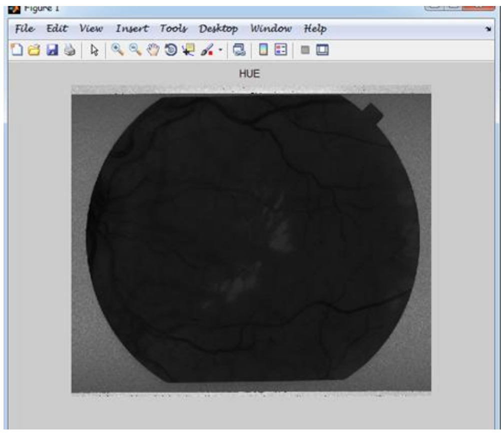

FIG 3.1.1 (b) HUE IMAGE

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Saturation component is given by:
S = 1 – [3 (R+G+B)][min(R,G,B)]

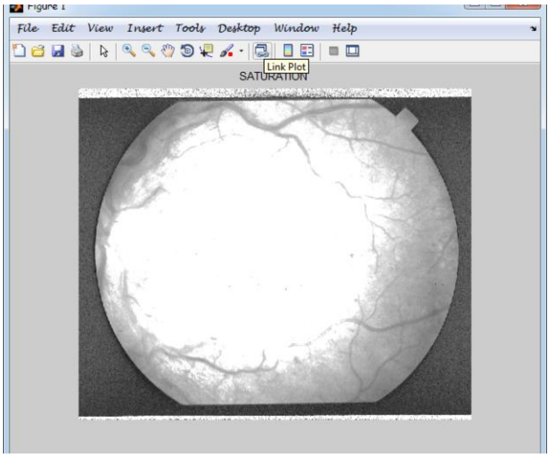

FIG 3.1.1 (c) SATURATION IMAGE

Intensity component is given by: I = 1/3(R+G+B)

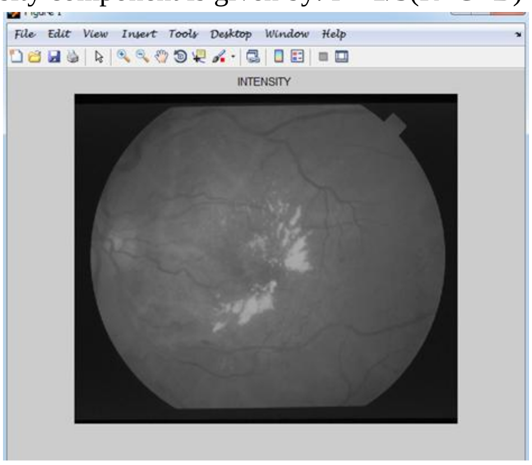

FIG 3.1.1 (d) INTENSITY IMAGE

3.1.2 MEDIAN FILTERING:

Median filtering is the best method for suppressing the isolated noise without blurring sharp edges. It changes the pixel by the value of median of all pixels in the neighbourhood of small sliding window. Median filter helps in removing the salt and pepper noise and horizontal scanning artifacts. During the image pre-processing, the salt and pepper noise is added to the intensity band and then it is filtered by using median filtering of 3*3 sizes.

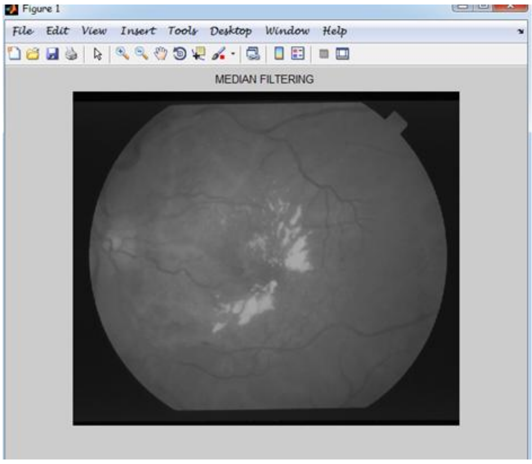

FIG 3.1.1 (e) IMAGE AFTER APPLYING MEDIAN FILTERING

3.1.3 ADAPTIVE HISTOGRAM EQUALISATION

The fundus images usually consists of the uneven illumination, the central area of the image is the brightest part of the image as compared to the sides of the image. Hence the brightness of the image decreases as we away from the centre of the image. To get uniform illumination, contrast limited adaptive histogram equalization is used. With the help of this the darker area of the input image becomes the brighter area in the output image. It keeps the uniform illumination in the image. The function adapthisteq () is available in the MATLAB which is used for applying Contrast-Limited Adaptive Histogram Equalization to resultant intensity band.

FIG 3.1.1 (f) IMAGE AFTER APPLYING CLAHE

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3.2 OPTIC DISK ELIMINATION:

The processed image is then used for optic disk elimination as follows:

The optic disk has various characteristics, out of which bright intensity is almost similar to the presence of exudates; the optic disk is initially detected and then removed to reduce the false positives. Initially the area of interest that is optic disk is chosen using the region of interest from the output of the pre-processed intensity image, by using **roipoly ()** function available in mat lab as I1. Taking the image with all ones as I2. Subtracting the image I1 from I2 to get I3 image. The I3 image is than multiplied with the intensity image I1, which gives the image with elimination of optic disk.
The image with optic disk elimination is = $(I_1 - I_2) * I_1$
Where $I_3 = I_1 - I_2$

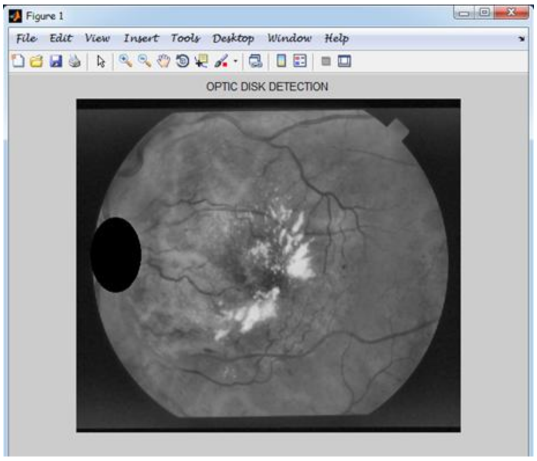

FIG 3.2 OPTIC DISK ELIMINATION

3.3 BLOOD VESSEL DETECTION:

Blood vessel detection is done as follows:

Blood Vessels detection [5]is the most important step in detection of exudates, as the presence of exudates are at the tip of blood vessels or above the blood vessels. The general steps of the blood vessels detection is as follows:

STEP 1) the input image is converted into gray scale image so to strengthen the appearance of the blood vessels in the image.

STEP 2) the average filtering and median filtering techniques are used for reducing noise from image and the redundant pixels from the image.

STEP 3) the adjusting of the contrast of an image by saturating the intensities by 1% so that the image is highly purified with no noises and impurities.

STEP 4) Applying canny edge detection by using a particular thresholding technique to the resultant image to obtain the vessels area.

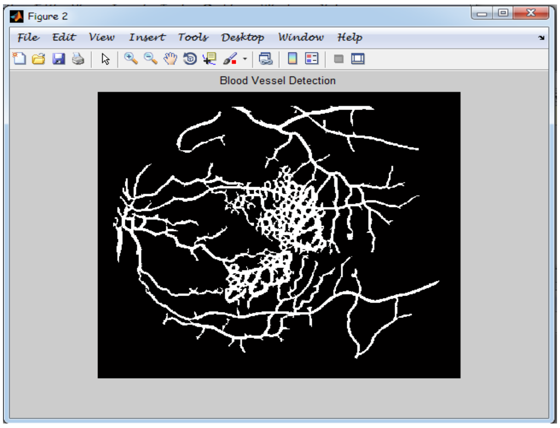

FIG 3.3 BLOODS VESSEL DETECTION

3.4 DETECTION OF EXUDATES:

This uses the adaptive thresholding method.Adaptive Thresholding [6] is basically used in scenes with uneven illumination where same threshold value is not usable throughout complete image. Small regions in the image are looked and obtain thresholds for individual sub-images. Final segmentation is the union of the regions of sub-images.Threshold value is to be set between 0.39 -0.94.For each pixel in the image, a threshold of intensity has to be calculated. If the pixel value is between the range of threshold value than we consider them as kind of an exudates[7]. There are two classes of exudates-True Exudates and False Exudates.
Now using morphological operator to superimpose the image[8]. Optic Disk Elimination + Blood Vessel Detection + Detection of Exudates If the threshold value of pixel lie on the blood vessels or in the macula region of an eye, macular region is the centre part of

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an image, than they are true exudates else they are false exudates.[9]

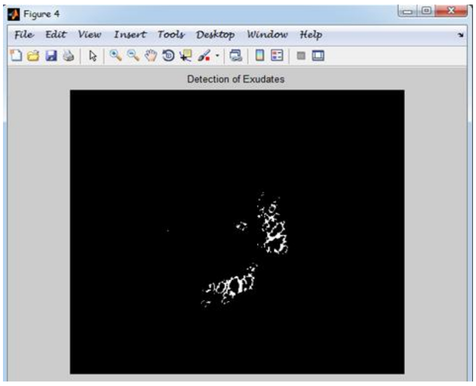

FIG 3.4 DETECTION OF EXUDATES

4. RETINAL DETACHMENT:

Retinal Detachment is one of the serious issue that needs extensive care if detected because it is an critical condition in which the retinal cells are pulled away or gets separated from layers of blood vessels that provide nourishment and oxygen to it. Retinal detachment can occur when the gel-like material (vitreous) leaks through a retinal hole or tear and collects underneath the retina. Aging or retinal disorders can cause the retina to thin. Retinal detachment due to a tear in the retina typically develops when the vitreous collapses and tugs on the retina with enough force to create a tear. Exudative retinal detachment occurs due to an underlying condition causing build up of fluid (exudates) between the neurosensory retina (photoreceptor layer) and the retinal pigment epithelium (RPE). Inflammatory conditions such as uveitis are the most common conditions responsible for this type of retinal detachment [10]. Other rare but more serious conditions such as choroid tumours can be responsible for Exudative retinal detachments too.

4.1. DETECTION METHOD:

The approach can be used by designing a technique in which the blood vessels are extracted and exudates are detected, then it is to be checked whether the amount of fluid released is more than a particular threshold value.

Because in case of Exudative retinal detachment large amount of fluid is released that causes the retinal detachment. The volume intensity can also help to detect whether retinal detachment is present or not.

5. CONCLUSION:

In this paper a brief description of Exudative retinal detachment was discussed along with that the process of detecting Exudates which help us to check whether a person is suffering from Diabetic Retinopathy or not. The paper mainly proposes a theoretic method to check the retinal detachment one of the biggest problem or can be stated as critical vision disorder.

6. FUTURE WORK:

Further work can be done on finding ways to detect other types of retinal detachment. Various techniques can be used to detect retinal detachment .Other than that more specific and accurate techniques can de designed to detect Hard exudates and soft exudates. Various algorithms can be designed and comparisons can be made with previous algorithms.

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