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Characteristic Analysis of Hard Exudates in Retinal Images

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1. ABSTRACT:

Hard exudates are the early detectable abnormality in diabetic retinal images. These are Yellow in colour and usually brighter than the background and also similar to the optic disc. So, Global Limits for Hue and Brightness can be used to define the preliminary macro search region. The definition for hue and brightness are computed with the R, G, B values of each image as a preprocessing. The lower and upper bound of hue are calculated and, the intensities are re-mapped by histogram linearization. Using the equalized Xb and Xh, the gross Value for average of Xb and the mean absoulte deviation for Xb from its gross average is found out. From these values, Lower and upper bounds on the Hues of the exudates can be set .Then create a gray image which is composed of R,G,B ,the lower ,upper bounds of the hue and brightness values are found ,called micro search and the points qualify for exudates are identified and detected. Also an iterative procedure and median filter could be conjectured to extract the left over exudates in the periphery of the detected points.

***Keywords*—Hard Exudates, Histogram equalization Hue, Diabetic retinal image , Brightness**

2. LITERATURE SURVEY:

The proposed work focuses on detecting & enunciating the characteristics of exudates. The early stage of the non-proliferative retinopathy is developed by the exudates which are caused by the leaking of proteins and lipids of the damaged blood vessels [3].The most primitive sign of diabetic retinopathy is exudates; these are caused from the escape of plasma and white blood cells from defective blood vessels. Vision loss can be prevented by detecting and removing the exudates. Detecting and localizing the exudates from low contrast retinopathy images with non-dilated pupils [4]. Various appearances changes of retinal fundus images and the mathematical model for detecting exudates [2]. The retinal images are preprocessed using LAB color space[5], median filter is suppress the isolated noise without blurring the sharp edges[13] through horizontal scanning artifacts, Carla Agurto et al proposed that by eliminating the non-uniform illumination detecting the candidate lesions using supervised classification with partial least squares[1]. To localize the optic disk and treat the confusion due to similarity between exudates and optic disk. The algorithm use specific color channels and some of image features to separate exudates from physiological features in digital fundus images [6].

The optic disc and Exudates both are have homogeneity property based on the color feature so the optic disc can be removed; optic disc is extracted & eliminated by canny edge detection [9] and background subtraction method [18]. A supervised support vector machine (SVM) is finally trained based on these features to classify the candidate regions for HEs [7]

Many of technique can achieve good performance on retinal feature are clearly visible. Unfortunately, it is a normal situation that the retinal images in Thailand are low-quality images. The existing algorithm cannot detect low-quality image. Therefore, this study is part of a larger effort to develop a new method for detection of exudates in low quality retinal image [8]

Pathologies of Diabetic retinopathy by FCM segmentation [11].Umer Aftab and Usman Akram et al [12] uses filter bank for candidate exudates detection. Based on Fisher's linear discriminate analysis of color information for exudates classification [10] and Xiang Chenetal proposes automatic detection of the hard exudates of candidate regions [7].

Diabetic Retinopathy is a worldwide severe disease, so early detection is must and the primary sign is hard exudates. Thus the detection of hard exudates at the early stage is [14] is mandatory. The professional work to examine every fundus image has been reduced by separating exudates in the abnormal image only[15],since the intensity and color distribution of OD region are same as that of exudates false hard exudates are formed. It has been removed and evaluating the performance by weighted error rate, but here the pixel wise accuracy yet to be detected.

A clear picture of the abnormality, its type (NPDR or PDR) classified based on the exudates [16]. The appearances of the blood vessels can provide information on pathological changes caused by diabetes, hypertension for the normal and abnormal images [17].

3. INTRODUCTION:

The images were taken from DIARETDB1 database[20]. This contains 89 colour images of the fundus which were captured using a digital fundus camera, with a field of view of 50º, at varying imaging settings in Kuopio University. These database images are widely used for evaluation of the performance of the various diagnostic procedures without performing any calibration. The size of these images was 1028 x 1152 bmp, which was resized to 256 x 197 bmp. This was done to accelerate the computation .The proposed method consists of micro and macro searching methods for the detection of hard exudates. The representation of retinal image is shown in Fig1.

Fig. 1. Retinal Image representation

Properties of the Exudates:

The hard exudates are Yellow in colour. These are usually brighter than the background and similar to the optic disc [19] could be detected and removed. So, Global Limits for Hue and Brightness can be used to define the preliminary macro search region.

The R, G, B values for brighter region and the background region of each and every image are calculated by hand as shown in Table 1.

Table.1 R,G,B,Hue of image # 001

Image 001			
R	G	B	Hu
151	78	2	.5132
153	88	4	.5714
166	84	9	.5030
168	88	4	.5207
171	107	6	.6221
174	83	12	.4743
177	112	6	.6292
192	144	6	.7461
AvR= 139	AvG= 68.8	AvB= 2.2	AvH= .4875
sgR= 10.9	SgG= 12.4	SgB= 1.33	SgH= 0.0482

4. PROPOSED METHOD:

PREPROCESSING:

MACRO SEARCH REGION

The image is preprocessed as hue and brightness images.

Hue:

The hue has been defined for convenience as hue (i,j) = 255.xg(i,j) / xr(i,j), which is the ratio of the intensity of the green to the red point located at (i,j). The factor 255 is useful for treating the Hue matrix as a grey image. This means that 256 hues are permitted.

Brightness: As far as the retinal images are concerned, the red component of the image appears to represent the Brightness fairly well. This is a Grey Image XR.

Consider the following:

function [Xhb]=HueBright(XR,XG,sx,sy);

The R component and the G component of the Image are inputs to the function **HueBright**. The Output XHb contains the two matrices Xh and Xb to represent Hue and brightness respectively as Xh=Xhb(:,:,1) and Xb=XHb(:,:,2).

Consider the next function:

[Xhb,Low_int,High_int,Low_Hu,High_Hu] = HuIntLimGen (XR,XG,sx,sy)

This uses the function **HueBright** to get the Hue matrix and Brightness matrix.Then Histogram Linearization is performed on the brightness image Xb and Hue Image Xh.

So parameters Hue has been introduced, However, this very variation gives diverse points probably would lie on well-defined line plots as well as quadratic fitting. Hence an attempt has been made to plot these variables with respect to XG. The reason for choosing XG as the independent axis is that the hard exudates appear sharper in the green-plane.

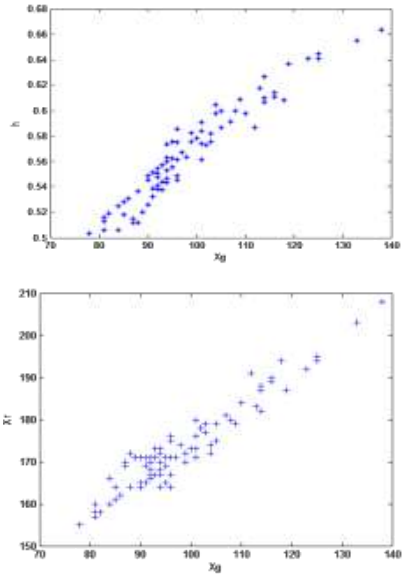

Fig 2 Characteristic curve of Hue Vs Green

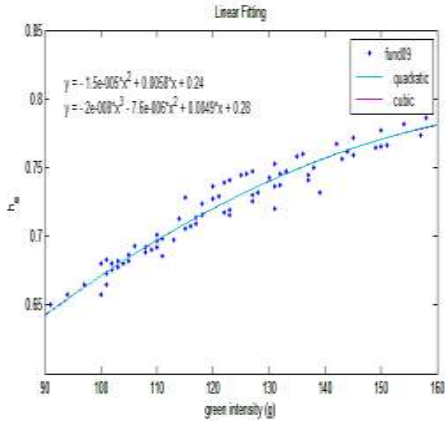

Fig 3. Linear fit of hue Vs Green

[Xb]=LinearHist(Xb,sx,sy); % This is a small program written
[Xh]=LinearHist(Xh,sx,sy); % for this application

The cdf is which have values between 0.0 and 1.0 appears to be non linear. The intensities are re-mapped for to yield a linear Cdf between 0 and 1.0;
So it uses another function for generating CDF and inverse linear CDF for a grey image XX of size (sx x sy) viz.,

[CdfInvCdf]= CdfAndInvGrey(XX,sx,sy)

Using the equalized Xb and Xh, the Gross Value for average of Xb and the mean abs deviation for Xb from its gross average is found out.

Using these averages, the Lower Limit and Upper Limit for the Intensity of Exudates can be set as [Low_int, High_int]
Similarly, the Lower and upper bounds on the Hues of the exudates can be set as [Low_Hu , High_Hu].

This process is explained below:

Low_int = uint8(gr_av+0.5*gr_sig); % Brightness Limits

High_int = uint8(gr_av+4.*gr_sig); % Brightness Limits

Low_Hu = uint8(h_av+1*h_sig) ; % Hue Limits

High_Hu = uint8(h_av+5*h_sig); % Hue Limits

For just doing this part a separate program was written, **'ExudColourMain.m' which** contain just the above listed functions. The coefficients 0.5, 4.0, 1.0, 5.0 have been arrived at after considering many images provided by the Eye-Specialist.

These weights are frozen.

5. MICRO SEARCH:

Coming back to the main Program for detecting the Exudates in a given retinal Image,

1.We separate the R, G, B components as XR, XG, XB.

2. We also build another Grey Image XRGB, which is composed of red, green, and blue components. This grey Image is used for micro search.

XRGB = (xb.xr/ 255 + xr.xg/255). This means that importance is given to the cross correlation between r and g components. The blue component, even though its brightness is very low, it certainly has the information on the exudates and the optic disc. So it has been added to create XRGB.

3. Further, we perform Histogram Linearization on the Grey Image XRGB as:

[XRGB] = LinearHist (XRGB,sx,sy);

4. Next, to get the Limits [Low_int, High_int] and [Low_Hu , High_Hu].

we call the function:

[Xhb,Low_int,High_int,Low_Hu,High_Hu] = HuIntLimGen (XR,XG,sx,sy)

5. Then point by point search of the image is carried out.

Let us take a typical point (i,j).

We will check whether the point falls within the broad region of Exudates defined by the above hue limits and Brightness Limits. If it does not fall within these limits, skip and go to the next point (i,j+1) and repeat. If it falls within the limits, then substantiate the presence of the exudates by micro search.

6. If the central point of the (fsiz x fsiz) filter,
{ a) exceeds the rgb-intensity-limit (av4+1.5sig4) and also
b) Exceeds the hue-limit (av5+1.25*sig5), while
c) Remaining within the higher-intensity threshold (av4+5 sig4) }

OR

{ If the central point of the (fsiz x fsiz) filter

a) exceeds the hue limit (av5+1.5*sig5)
b) exceeds the rgb-intensity limit (av4+1.25*sig4), while
c) remaining within the higher Hue limit (av5+3.5*sig5); }

Then, the point p(i,j) qualifies for an exudate.
The various limits were arrived by analyzing about 20 images.
The above scheme is a very diminutive form of fuzzy logic and the rules has been given here.
For this detected exudes, the average in the ring around it is passed out as the output.
a1 is the average for the R (fsiz x fsiz) segment;
a2 is the average for the G (fsiz x fsiz) segment;
a3 is the average for the B (fsiz x fsiz) segment;

6. TOUCHING UP THE EXUDATES:

The averages are used to fill the corresponding spots in the original image.
This could be thought of as touch up.

Table.2 Rules for Fuzzy approach if required

Items			Rules For Exudates	Rules for no exudates
Av_xr0	av_xr1		av_Xr1 > av_xr0	Av_Xr1<xr0
av_xg0	av_xg1	av_xg2	(av_xg1||av_xg2)> av_xg0	(av_xg1||av_xg2)<av_xg0
diff0/av_xg0	diff1/av_xg1	diff2/av_xg2	(d1||d2)< d0	(d1||d2)>d0
sum0	sum1	sum2	(sum1||sum2)> sum0	(sum1||sum2)<sum0
av_h0	av_h1	av_h2	(avh1||avh2)> av_h0	(avh1||avh2)<av_h0
m0	m1	m2	(m1||m2)< m0)< m0	(m1||m2)< m0)> m0
c0	c1	c2	(c1||c2)> c0	(c1||c2)<c0

7. EXUDATES DISPLAY IN B & W AND COLOUR:

Also a symbol x0 = 255 is passed into an initially empty matrix [X0].
Eventually the detected exudates appear as a bright spot in Black Background.
There is a provision for passing more parameters like the (r,g,b) values
(like xr,xg, xb) of the point designated as exudates. This will help to form a colour image of the exudates if desired.

8. ITERATION:

While there may not be a complete detection of exudates, an iterative procedure could be conjectured to extract the left over exudates in the periphery of the detected points.

For the next iteration, we create a new image with components (YNER, YNEG, and YNEB) and Load them respectively into XR, XG, XB and repeat all the listed steps, including the formation of XRGB, Gross averages, various coarse limits for brightness and hue, micro search, touch-up, and so on. Ultimately YNEx matrices will contain no exudates.

A few more exudates are detected, further on the new XR, XG, XB, makes it still devoid of the exudates. About 5 such iterations may be enough to extract all the exudates. The exudates are separated as a black and white image.

In the touched up image, the average colour is painted, to make them somewhat invisible.
The black and white display of the exudates can be median-filtered to remove the random spots.

9. RESULTS:

The images are taken from database and hue of particular image has calculated given as input are 4.a

The results have been shown in Fig 4.b and 4.c

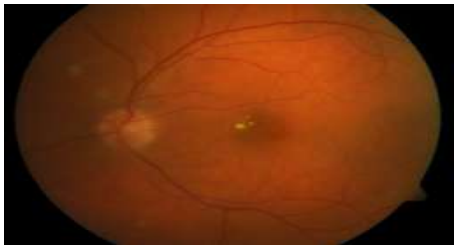

Fig 4.a Retinal image

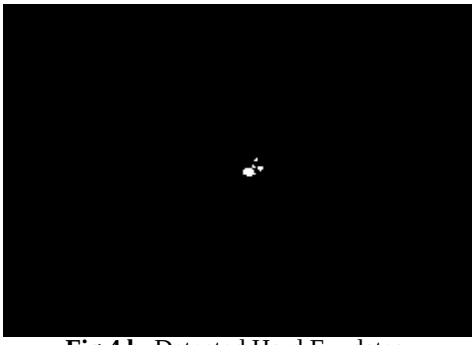

Fig 4.b. Detected Hard Exudates

For some stay cases median filter has been used, then the results are shown like this

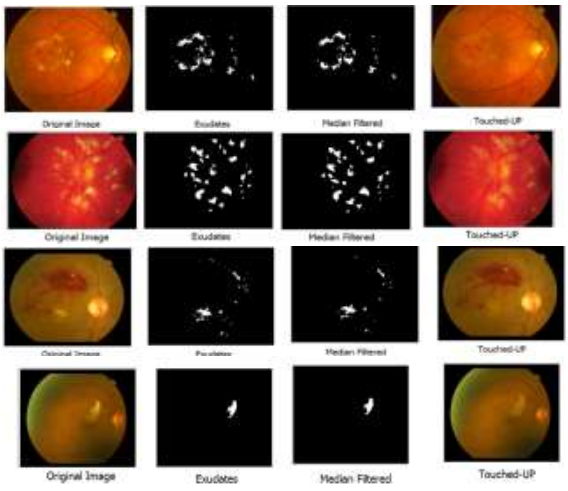

Fig 4.c. Detected Hard Exudates

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