An Effective Method for Retinal Image Enhancement Based on Illumination, Luminosity and Contrast

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Abstract – Retinal images can provide plentiful information of many diseases, which are widely used by doctors such as ophthalmologists for diagnosing various disease related to eye and heart. Due to sore bad, gleaming, dim which occurs in the retinal image may lead to uneven detection of diseases by ophthalmologists. And it causes so many problems to that field in order to diagnosing and specification of diseases. To avoid such problems, here introducing a new proposed enrichment method for retinal images based on gleaming similarity, luminance of image and adjustment of image contrast. The gleaming similarity method is used to surpass the non-uniform illumination effect of the image. The common problem of uneven variance color occurs in the image which is overcome by the processes which are implemented on the luminance channel of the image color space. To blow up the RGB channels the matrix of gain occurs from the luminance of variance will used in the HSV channel (Hue, Saturation, and Value) color space. Accordingly, the method CLAHE (contrast limited adaptive histogram equalization) which is used in the channel L*a*b* color space can achieve enrichment in the variance of contrast of image and preserve bogus contrast. This method will give enriched color retinal image and it is easy to detect diseases and visualize the image. The proposed method is valued on a data subset of quality less retinal images that available publically.

Index Terms – Illumination Equalization, gamma correction, gleaming, color retinal image.

1. INTRODUCTION

Image enhancement has pivotal benefaction in ophthalmology, particularly in retinopathy diabetic in spotting micro aneurysms. The spotting can be done by the ophthalmologist or robotic spotting using image processing technique (known as Computer Aided Diagnosis / CAD). The fundus camera is a prevailing imaging modality in eye hospital or clinics, we can use this camera to obtain retinal image. Fundus photography involves capturing a photograph of the back of the eye. The main structures that can be visualized on a fundus photo are the central and peripheral retina, optic disc and macula. The image streak that is reliant on the acquisition method, for example, brightness, a winking and eye movement. The image quirk is very essential, due to the substance that the ophthalmologist use this image to verdict purpose. If there is some noise in the image, this will decrease the tact and specificity. The examples of good and quality less of color retinal image are shown in Fig.1.

(a) (b)

Fig.1. (a) Good and (b) poor quality of color retinal image

There are some crucial visages in color retinal image that are: color and contrast (especially optic disc and blood vessels).Due to the uneven gleaming, noise may appear in the image. To reduce this noise effect in color retinal image due to the uneven gleaming, we need to enhance this image. Color retinal image has ideal characteristic than other image, that is, this image has essential features in green (G) channel, due to the fact in the channel, which is the blood vessels appear much contrast than the background.

The existing methods can broadly be divided into three types: histogram based, filter based, and transformation based. Most of these methods are gist on enhancing retinal blood vessels to clinch better vessel segmentation through increasing the contrast brightness between blood vessels and the retinal background in both grayscale and color retinal images. This method is especially useful for color retinal images to rectify diseases, where the green channel of the color retinal image generally shows a high variance between the vessels and the background of the image. The enriched retinal images can mislay color features or other important features in the image (e.g., optic disc, macula lutea, and various types of sores), which cannot directly adorn the current clout of diagnosis by ophthalmologists.

To obtain added image features as well as conserve the artlessness of the image which means amusing streak without distortion of the color and over-enrichment, here introduce a new enhancement method for color retinal images placed on gleaming equalization, luminosity and contrast adjustment. To convert the non-uniform color retinal images into uniform, gleaming equalization is used.

A luminance gain matrix which is used to enhance the R, G, and B (Red, Green and Blue) channels, that is gained by gamma correction of the value channel in the HSV (Hue, Saturation, and Value) color space, relevantly. The luminosity channel of L*a*b* color space by CLAHE (contrast limited adaptive histogram equalization) which is used to enhance the features of disparity. Image enhancement by the proposed method which is compared to other methods by rating quality scores of the enhanced images. The method is valued on a publicly-available dataset and data subset of quality less retinal images.

2. RELATED WORK

Generally, the contrast enhancement methods can be categorized into divergent classes based on Histogram, Transformation, Masking and Filter [1, 2]. But this review paper represents Histogram Based methods such as Histogram Equalization (HE), Adaptive Histogram Equalization (AHE), Contrast Limited Adaptive Histogram Equalization (CLAHE), Rayleigh Contrast Limited Adaptive Histogram Equalization (Rayleigh CLAHE), Non Uniform Sampling, Vessel Enhancement Via a Multidictionary and Sparse Coding (VE-MSC).

- Histogram Equalization (HE)
- Adaptive Histogram Equalization (AHE)
- Contrast Limited Adaptive Histogram Equalization (CLAHE)

2.1. Histogram Equalization (HE)

Histogram equalization is one of the variance enrichment methods which consist of low computation load. This technique is used to enhance the surfacing of image by disbursing the intensity values of the pixels evenly (i.e. a flat histogram). Although to obtain a perfect image, it is important to have all the gray levels with similar number of pixels. Hence, it turns required not only to obtain similar distribution but also to have similar number of pixels in all the gray levels [3].

It is a easiest method to enhance the contrast of the retinal image. Therefore, HE is not a best enough method for retinal images because of its huge noise of intensity and the loss of some luminance levels even after assigning the enrichment method. It generates best outcomes in ordinary images such as human portraits or natural images [4, 5]. HE provides somewhat improvement in the contrast and blood vessels of the image.

2.2. Adaptive Histogram Equalization (AHE)

Adaptive histogram equalization method upgrades overall histogram of sub-image adequate to redeploy the glare value of the images [3]. Even, Histogram Equalization (HE) entirety on the full image but it nurtures less improvement in the image. Adaptive Histogram Equalization (AHE) which enhance the parish variance of a retinal image. Hence, AHE brings out more details than HE [6].

2.3. Contrast Limited Adaptive Histogram Equalization (CLAHE)

Contrast Limited Adaptive Histogram Equalization *(CLAHE)* is used to enhance the contrast of the image, which raises from AHE method [7]. It is a method for enhance the retinal vessels of an image. AHE aired amplifying noise in some of the regions that is homogenous, thus to solve such uneven problem CLAHE method was proposed. In CLAHE method, the input image is splitted into three image channels [Red (R), Green (G) and Blue (B)].

2.3.1. Rayleigh CLAHE

Rayleigh transformation in Contrast Limited Adaptive Histogram Equalization is used to enhance the intensity component of the image (Rayleigh CLAHE) [9]. In CLAHE method, the image will contain better contrast but the chromatic information that will not be conserved. In Rayleigh CLAHE, it will improve the quality of contrast as well as conserves chromatic features in retinal image. Thus, it improves the overall appearance.

2.3.2. Non- Uniform Sampling

Non-uniform sampling method helps to catch the correction factor plying the degradation components. The normalized correction factor when implemented on all three (R, G and B) planes which will gives an improved contrast for non-uniform gleaming successfully. Thus, it enlightens the overall diversity and endows a nominal shift in the color content. So, no latest artifacts were introduced [10].

2.3.3. Vessel Enhancement via multi-dictionary and sparse

In this method, the Representation Dictionary (RD) and the Enhanced Dictionary (ED) two corresponding dictionaries are generated. The patches in RD and ED are selected through the information images. To amend the multi dictionary, the patches are extracted only by the use of green channel. This enhancement method not only improves the image contrast level but also enlighten the vascular structure of the retinal. Hence, it yields more details of retinal images [11].

3. PORPOSED MODELLING

The architecture diagram of proposed color retinal enhancement method is shown in Fig. 2.

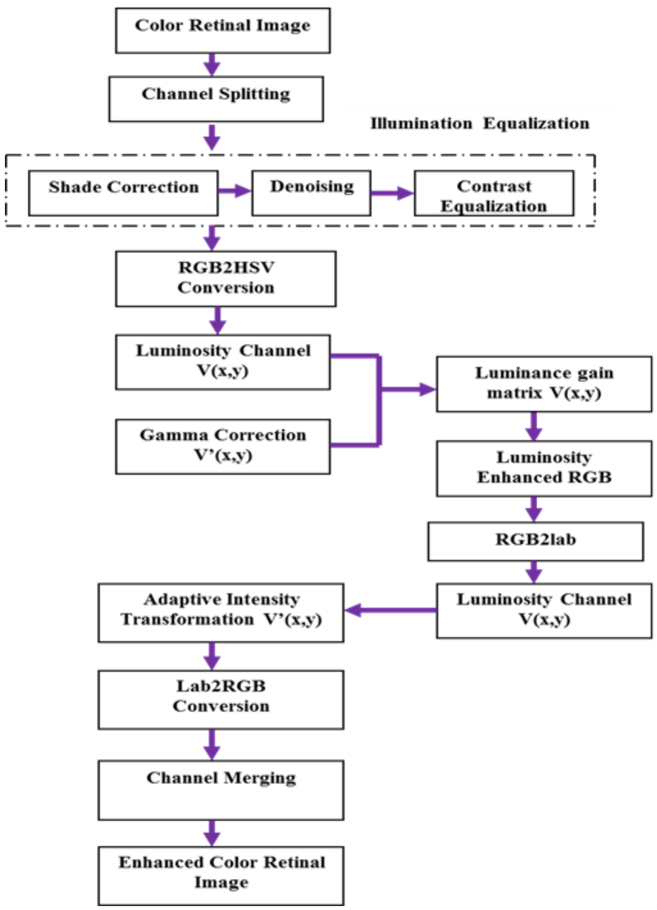

Fig.2. System Architecture

The proposed enhancement method is used to enrich color retinal image illumination, luminosity and contrast. Illumination equalization process to enhance the retinal image is gained by shade correction, de-noising and contrast similarity. To enhance the R, G, and B (Red, Green and Blue) channels, a luminance gain matrix, which is acquired from the value channel in the HSV (Hue, Saturation, and Value) color space, is used to enhance the R, G, and B (Red, Green and Blue) channels by gamma correction, gradually. Then, CLAHE (contrast limited adaptive histogram equalization) method is used to enhance contrast in the luminosity channel of L*a*b* color space. The proposed method includes three steps which are given below:

- Illumination Equalization
- Luminosity Enhancement
- Contrast Enhancement

3.1. Illumination Equalization

The glow of the retina is often non-uniform, directing to local or fake luminosity and contrast variation. To transform the non-uniform retinal into uniform, illumination equalization method is used. Sores may be faintly appears in the areas of bust contrast and/or low brightness. Moreover, in a telemedicine context, images are unfixed in terms of color and uniqueness.

3.1.1. Shade Correction

In the illumination equalization method, the shade correction is used to overcome the rendering effect.

$$I_{ie} = I + \mu - I * h_{M1}. \quad (1)$$

Large mean filter of diameter is implemented to each color feature of image in order to evaluate its illumination. Finally, the potency average μ of the original channel in the image is raised to preserve the same color range as in the original image.

3.1.2. De-noising

It is used to remove unwanted features from the image. A small strive filter of diameter is implemented to each channel color of the out coming image. It also reduces the noise that resulting from the acquisition and compression steps without smoothing the sores.

3.1.2. Contrast Equalization

The brightness drift in the contrast is verged on using local standard deviation evaluated for each pixel of diameter and color channel (I_{std}). Areas which have low standard deviation denote either low contrast or smooth background.

$$I_{ce} = I_{dn} + \frac{1}{I_{std}}(I_{dn} * (1 - h_{M3})). \quad (2)$$

To enlighten low contrast areas, the details in particular regions should be sharpening using formula for each value in color channel separately. The particulars are gained using a high pass filter, obtained from a diameter of mean filter.

3.2. Luminosity Enhancement

Due to unwanted light or uneven luminance it reflects poor visual perception of retinal images, so that diagnosing the details of diseases is undetectable. It is required to improve the luminance effect of the image first. However, for a color image, it is important to note that the color of any pixel should not change. In general, color retinal images are saved and viewed using RGB color space. The R, G, and B channels are simultaneously correlated with each other and contain the gleaming information and the brightness information. Our solution is to gain a luminance gain matrix $G(x, y)$ which is defined:

$$\frac{a'(\mathrm{m,n})}{a(m,n)} = \frac{b'(m,n)}{b(m,n)} = \frac{c'(m,n)}{c(m,n)} = E(m,n) \quad (3)$$

In the pixel at (m, n) position, where $a'(m, n)$, $b'(m, n)$, and $c'(m, n)$ are the enhanced R, G, and B values and the $a(m, n)$, $b(m, n)$, and $c(m, n)$ are the original R, G, and B variance of values. The H and S channels are unrelated to luminance and both are rejected. The intensity of a pixel in the luminance at the (m, n) position is obtained as the maximum (max) of the R, G, and B values. Therefore, the luminance gain matrix can be inferred as;

$$E(m,n) = \frac{S'(m,n)}{S(m,n)} = \frac{S'(m,n)}{\max(a(m,n), b(m,n), c(m,n))} \quad (4)$$

Where S(m, n) is the dazzle intensity of a pixel at (m, n) position, and S'(m, n) is the variance of S(m, n), which denotes the effect of luminosity enhancement.

3.1.1. Gamma correction

It is a popular imaging processing methods, is used to transform radiance nonlinearly. The transformation curve is expressed by:

$$v = u^{\gamma} \quad (5)$$

Where the normalized pixel value of the luminosity channel u $\in$ [0, 1] determines, v is the regularized output, and γ is a constant function. The luminance gain matrix values $E(x, y)$ are always greater than or equal to 1. Although, the HSV color space can effectively take care of the gamut problem for the gleaming enhancement [23]. The gray level range in the gamma correction does not change. The enhanced values a'(m, n), b'(m, n), and c'(m, n) by accumulating the original R, G, and B values of the variance and E(x, y) of luminance cannot implode of limits.

3.3. Contrast Enhancement

The retinal images are used to detect diseases in the eye as well as heart. The above process will enrich the gleaming effect of the image. It is important to enrich both luminance and contrast equally. To supplementary enrich the contrast of retinal images, the CLAHE method is applied, which has evaluated as an effective process to enrich the features of retinal images uniformly without collapse. The CLAHE split the areas and evaluate the histogram similarly to enrich the retinal image.

This contrast enrichment will only concern on the gleaming channel and can avoid the gamut problem by equalizing the histogram of the image (tile). The L*a*b* color space also called CIE LAB based on the prior master space CIE 1931 XYZ color space can contain large number of similar color variance in relation to visual variance. It has three orthogonal measures: gleaming and chromaticity. The CLAHE enhancement method is used to enrich the channel L. Then the L*a*b* color space is changed back into the RGB color space for the progresses image. For the device-independent data, the gleaming enriched image in color space of RGB is changed to the color space of CIE 1931 XYZ and then transformed into L*a*b* color space.

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix} = \begin{bmatrix} 0.412455 & 0.357585 & 0.180435 \\ 0.212680 & 0.715165 & 0.180455 \\ 0.019340 & 0.119195 & 0.950230 \end{bmatrix} . \begin{bmatrix} a'(m,n) \\ b'(m,n) \\ c'(m,n) \end{bmatrix} \quad (6)$$

$$M = 116 f(Y/Y_n) - 1 \quad (7)$$

Where CIE XYZ color space which consists of three elements they are X, Y, and Z, and the CIE XYZ tri-stimulus elements of X_n, Y_n, and Z_n are values of the reference white in the image.

4. RESULTS AND DISCUSSIONS

The enhanced color retinal images performance are calculated based on the illumination equalization, luminosity and contrast adjustment. This enhanced method was mainly resolved, justified and certified on the Messidor dataset. The original and enhanced images quality and nature has been evaluated by the proposed method**.** All the functions were achieved using MATLAB R2013b on a PC with Intel i3 processor at 2.30 GHz and 8 GB RAM.

The proposed method of color retinal image enrichment in the steady process with the original image (Fig. 3a), implementing illumination equalization to transform into uniform image (Fig. 3b), leading to gleaming enrichment to equalize the luminance (Fig. 3c), and ending with contrast enhancement to enrich the contrast of the particular retinal image (Fig. 3d) is shown for representative images. This process shows that our proposed method achieves better out coming results than the existing. It is an effective and ritual method for contrast enhancement by spreading the histogram of the processed image. The gleaming enhancement can improve the contrast to some extent.

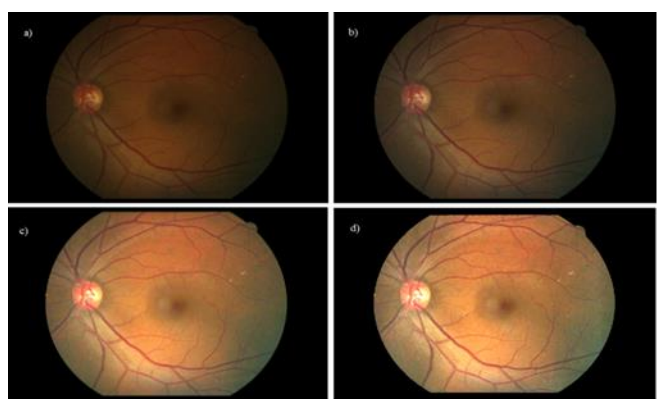

Fig.3. Proposed enhanced Image (a) Original retinal image (b) Illumination equalization(c) luminosity, and (d) contrast

The out coming retinal image enriched by our proposed method shows added visualization of the image and it gains an effective visualization of the blood vessels in the image. And also other required anatomical structures of the retina (i.e., optical disc and macula), and reduces the noise and gives better quality. Moreover, this method preserves the naturalness of the retinal images and restricts the formation of fake boundaries.

The evaluation of our method is performed on a Messidor dataset. The proposed quality assessment methods consider five metrics that are mean, standard deviation (SD), and edge based contrast measure (EBCM), energy and entropy. Now, let's see the comparison table of existing and proposed work based on the performance of both enhanced images. Here, this table will help us to know the improvement and performance of the proposed work.

	Orginal Image	***HSV***	***LAB***
Average score	0.0191	0.2762	0.3253
SD	0.1369	0.4471	0.4685
EBCM	1.5400	22.9160	23.1353
Energy	9.3569	376.3923	434.6580
Entropy	0.1364	0.8502	0.9100

Table I Assessed Scores of Original, HSV and LAB

The assessment result demonstrates that our method can improve the normal retinal images, too. When the retinal image is collected, it can be directly processed by the proposed method without prior assessment. By comparing the assessed scores of the two datasets, the average of the enhanced images in the Messidor dataset is slightly better in general, but the average of the original images is significantly higher. Despite the good quality achieved with enhanced images in both datasets, our method performs better on the poor quality retinal images in our proprietary dataset.

In summary, the above out coming shows that our proposed method works well on the quality less and poor retinal images to enrich their gleaming and contrast of light, and provides qualitatively and quantitatively superior and better enhancement.

5. CONCLUSION

Here, proposed an effective method for color retinal image enhancement based on illumination equalization, luminosity and contrast adjustment. Firstly, gleaming similarity is done using shade correction, de-noising and contrast equalization to transform the non-uniform image for better result. After that, the luminosity enhancement is done by using luminance gain matrix based on gamma correction. Next, the CLAHE method is used to enrich the contrast of the image in the in the L*a*b* color space. The performance of the proposed method was implemented and validated on messidor dataset which is publically available. The out coming enhanced image shows that our proposed method which gives an effective result when compared with existed work. This image can also used to ophthalmologists to detect diseases very easily.

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