Image Enhancement using NHSI Model Employed in Color Retinal Images

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ABSTRACT--*To produce an enhanced retinal image using enhancement technique because uneven illumination, image blurring, and low contrast retinal images with poor quality are not useful for medical diagnosis. Here we propose a new image enhancement method to improve color retinal image luminosity and contrast which include improving the intensity of the image. Luminance gain matrix is done. Contrast is then enhanced in the luminosity channel of L*a*b* color space by CLAHE (contrast limited adaptive histogram equalization).A method known as nonlinear hue-saturation-intensity color model (iNHSI) to preserve color information of the retinal images is used. Image enhancement by the proposed method is compared to other methods by evaluating quality scores of the enhanced images. This model in color retinal image enhancement may be employed to assist ophthalmologists in more efficient screening of retinal diseases because we get clear image and enhanced image as a result which helps in development of improved automated image analysis for clinical diagnosis.*

Keywords**--***Contrast enhancement, iNHSI gamma correction, L*a*b* color space, luminosity channel, retinal image.*

I. INTRODUCTION

We all know that we are gifted to see the beauty of nature through our precious eyes. Eyes are the sense organ which shows everything and through which we can see the near and far away objects. Eyes should be protected from the dust and other diseases related to the eyes. Parts of the eye are Cornea, Sclera, Conjunctiva ,Iris ,Pupil ,Aqueous ,Lens , Schlemm's Canal ,Vitreous body ,Retina ,Macula ,Choroid ,Optic nerve. In this project we are concentrating on the most important part of the eye Retina. Common eye diseases and cardiovascular diseases can be diagnosed through retinal imaging[1]. Due to uneven imaging and image blurring and poor quality of retinal images ophthalmologists find difficulties in finding the diseases related to eyes like diabetic retinopathy and age related macular degeneration and glaucoma[2]. Ophthalmologists find difficulties because retinal images are of a clinically unsatisfactory quality due to eye lesions and imperfect imaging processes [3], [4], such as haemorrhage, opacity of refractive media, and patients' eye movement. Poor quality images will create more difficulties leads to loss of sensitivity and specificity for diagnostic purpose and may even impair ophthalmologists' ability to interpret significant eye features or distinguish different retinal diseases [5]. Poor quality retinal images make it difficult for subsequent accurate segmentation and computer-aided diagnosis of retinal diseases [6], which are used to automate the detection process and to assist ophthalmologists. Therefore, it is necessary to overcome the challenges associated with poor quality retinal images. One effective method is to use image enhancement technology [7] to provide better visibility of the retinal anatomical structure.

In previous paper they use the classical histogram equalization, for increasing image quality using image luminosity and contrast normalization techniques [8], and a multi-scale method based on the Contourlet transform [9], Contrast Limited Adaptive Histogram Equalization [10]-[12], Retinex-based enhancement algorithm [13], [14], used to find blood vessel enhancement by multi-scale top-hat transformation and linear stretching with histogram Gaussian curve fitting [15]. Most of the methods used before focus on enhancing retinal blood vessels to achieve clear vessel segmentation through increasing the contrast between blood vessels and the retinal background in both grayscale images and color retinal images. This method is especially useful for color retinal images, where the green channel of the color retinal image generally displays a high contrast between the vessels and the background. The enhanced retinal images can lose color information or other important image features, which cannot directly improve the diagnosis process by ophthalmologists. We need to find a new enhancement method which increases contrast and luminosity and preserving the nature of the image. The process are conducted in luminosity channel[16].Luminance gain matrix is obtained from the anon-linear transformation of 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 respectively. Subsequently, contrast is enhanced in the luminosity channel of L*a*b* color space [17], [18] by CLAHE, which specializes in improving local contrast and avoiding the non-homogeneous regions in retinal images (the optic disc region is significantly brighter than other regions) and enhances the image uniformly and the enhanced image obtained is again enhanced using Nonlinear Hue Saturation Intensity to preserve the originalityand clear quality of image[19][20][21].

II. RELATED WORKS

Contrast enhancement is a technique applied to a digital image to qualitatively improve the contrast of image. This technique allows modified manipulation of the dynamic range such that the results are more informative for human eye. The Histogram Equalization (HE) which has good performance in ordinary images, such as human portraits or natural images. However, HE is not a good choice for the retinal images due to its amplification of the noise and the absence of some brightness levels after enhancement. It has been generalized to a local histogram equalization which is known as adaptive histogram equalization (AHE). AHE is based on HE that the adaptive method formulates each histogram of sub-image to redistribute the brightness values of the images. AHE is suitable to improve the local contrast of an image and to bring out more details. However, The problem remain the same with the global histogram equalization because of amplifying noise in relatively homogeneous regions.

An algorithm to enhance a color medical image has reserves the chromatic information to support the correct decision of a doctor in the image diagnosis step. In our algorithm, color model no gamut problem, iNHSI, is provided to keep the chromatic information. To improve the contrast of the color retinal image, the intensity component is employed to enhance by using Rayleigh CLAHE. The proposed algorithm is illustrated in Fig. 1. In the algorithm, a color retinal image is transformed from RGB to iNHSI color model. The chromatic data(hue and saturation) are preserved and the intensity component, J, is employed to enhance the contrast of the color retinal images[29][30]. The intensity, J, is the analysed brightness levels which are classified into two categories of exposure levels: under-exposure, and over-exposure. The exposure levels are used to declare a set of parameters of CLAHE that consist of clip-limit value and 0: value in Rayleigh distribution. Finally, new intensity, 1', which was enhanced, is provided to combine with the hue and saturation components to invert the transformation to RGB color model.

A) NONLINEAR USI COLOR MODEL

A perceptual color model, HSI(Hue, Saturation, Intensity), is widely used in color image processing. In our color image enhancement, the intensity values are modified. When HSI is transformed back to RGB color model for displaying, out-of-gamut problem is usually occurred because some color pixel values are out-of-range of the RGB color space. To avoid this problem, iNHSIcolor model is provided to preserve the color information of the retinal images.

B) RETINAL IMAGE EXPOSURE

An image capturing device is sensitive to light. If the light is less than necessary, the image will be underexposure; vice versa, if the light is more than necessary, the image will be over-exposure. Fig. 3 illustrates two color retinal images, which represent the under and over exposure as shown in the figures (a) and (b), respectively. As seen in the histograms of the images, the red band of the color retinal images usually has higher intensity levelsthan the others. The under exposure image does not have an effect of out-of-gamut. However, the over-exposure has this effect by the red band

According to both the cases of over and under exposure, an image will have low contrast. In the color retinal images, the intensity component is provided to measure the exposure situation by analysing skewness of the intensity histogram. The skewness is calculated in the region of interest(ROI), which consists of the retinal area. Thus, the retinal image is identified by the exposure status as the following steps.

Step 1: Select the ROI from the intensity component by using a threshold value of Otsu method

Step 2: Calculate mean of the ROI data in set A{ al, a2, a3, ... , an} of 17, elements that is given by

$$\mu_A = \frac{1}{n}\sum_{i=1}^{n} a_i \quad (1)$$

Step 3: Identify the skewness of ROI to define the exposure stage of each input image. The identification method is provided by calculating two regions of set A.

The region, $Area_L$, consists of the intensity values less than. Otherwise, $Area_R$region has intensity values.

$$Area_L = \sum_{k=0}^{\mu_A} \frac{n_k}{n} \quad (2)$$

$$Area_R = \sum_{k=\mu_A+1}^{L-1} \frac{n_k}{n} \quad (3)$$

Where nk is a number of pixels in set A having graylevelk in the range [0, L - 1] and L is total number of gray levels. The skewness of ROI is evaluated by comparing the parameters, $Area_L$, and AreaR- If AreaLis more than Ar-eaR, it means that the input image has majority of under-exposure; vice vera, if Ar-eaR is more than Ar-eaL, then input image has majority of over-exposure histogram of ROI from Fig. 2(c), 2(d) which are defined as under-exposure and over-exposure, respectively.

C) RAYLEIGH CLAHE

In our algorithm, two parameters of Rayleigh CLARE: clip - limit and a value are declared depending on an input data. Clip-limit value is used to protect the over enhancement. CLARE method restricts the amplification by clipping the histogram at a user-defined value called clip-limit[31][32]. The clipping level determines how much noise in the histogram. It should be smoothed and hence how much the contrast should be enhanced. a parameter in Rayleigh distribution is provided to control the designation of the transfer functions in each region. Generally, the parameter endows to control a shape Rayleigh distribution. Although the proposed parameter may generate continuous local transformation under the proper conditions by assigning carefully the parameter to an individual image, the continuity cannot be proved and is not guaranteed. If there are big changes between nearby local histograms, the local intensity level transformation will be changed abruptly.

III . LITERATURE SURVEY

A. Enhancing retinal image using Contourlet transform

The evaluation of retinal images is widely used to help doctors diagnose many diseases, such as diabetes or hypertension. Due to the acquisition process, retinal images often have low grey level contrast and dynamic range. This problem may seriously affect the diagnostic procedure and its results. It is a multi-scale method for retinal image contrast enhancement. It has good performance in representing edges, and is therefore well-suited for multi-scale edge enhancement. In this Contourlet coefficients corresponding sub bands via a nonlinear function take the noise into account for more precise reconstruction and better visualization. The application of this method on images from the DRIVE database showed that the proposed approaches performs other enhancement methods on low contrast and dynamic range images, which is helpful for vessel segmentation.

B. Retinal vessel enhancement based on multi-scale top-hat transformation and histogram fitting stretching," Opt. Laser Technol., vol. 58, pp. 56-62, Jun. 2014.

Retinal vessels play an important role in the diagnostic procedure of retinopathy. A new retinal vessel enhancement method is proposed in this paper. Firstly, the optimal bright and dim image features of an original retinal image are extracted by a multi-scale top hat transformation. Then, the retinal image is enhanced preliminarily by adding the optimal bright image features and removing the optimal dim image features. Finally, the preliminarily enhanced image is further processed by linear stretching with Histogram Gaussian curve fitting[25][26][28]. The experiments results on the DRIVE and STARE databases show that the proposed method improves the contrast and enhances the details of the retinal vessels effectively.

C. retinal Blood vessel enhancement via multi-dictionary and sparse coding: application of retinal vessel enhancing

The Bloodvessel enhancement is based on multi-dictionary and sparse coding. Two dictionaries are utilized to gain the retinal vascular structures and details, one is the representation dictionary (RD) generated from the original retinal images, and another is the enhancement dictionary (ED) extracted from the corresponding label images. This method represents the input image with RD to get the sparse coefficients via a sparse coding process. Then the enhanced retinal vessel image is obtained from the solved sparse coefficients and ED. Experimental results performed on the DRIVE and STARE databases indicate that the proposed method not only can effectively improve the image contrast but also enhance the details of the retinal vessels.

D. Luminosity and contrast normalization in retinal images

Retinal images are routinely acquired and assessed to provide diagnostic evidence for many important diseases, e.g. diabetes or hypertension. The images are non-uniformly illuminated and they exhibit local luminosity and contrast variability[27]. This problem may seriously affect the diagnostic process and its outcome, especially if an automatic computer-based procedure is used to derive diagnostic parameters.A new method is brought to normalize luminosity and contrast in retinal images. This method is based on the amount of luminosity and contrast variability in the background part of the image and the subsequent compensation of this variability in the whole image[22][23]. This method of images showed an average of 19% reduction of luminosity variability and an average 34% increment of image contrast, with a remarkable improvement e.g. over low-pass correction. The proposed image normalization definitely improves automatic fundus images analysis

but will be very useful to eye specialists in their visual examination of retinal images

IV. PROPOSED METHOD

The work presented in this study consists of threemajor modules:

- **CHANNEL SPLITTTING**
- **LUMINOSITY ENHANCEMENT**
- **CONTRAST ENHANCEMENT**

A) CHANNEL SPLITTTING:

The original input color retinal images are stored and viewed using RGB color space. The R, G, and B channels simultaneously contain the luminosity information and the color information, which are correlated with each other so it is not suitable for luminosity and color enhancement hence RGB color space images are converted into HSV and LAB color space. The conversion from RGB color space to LAB and HSV color space is governed by following formula.

$$M = \max(R, G, B)$$
$$m = \min(R, G, B)$$
$$C = M - m$$
$$H' = \begin{cases} \text{undefined}, & \text{if } C = 0 \\ \frac{G-B}{C} \mod 6, & \text{if } M = R \\ \frac{B-R}{C} + 2, & \text{if } M = G \\ \frac{R-G}{C} + 4, & \text{if } M = B \end{cases}$$
$$H = 60^\circ \times H'$$
$$V = M$$
$$S_{HSV} = \begin{cases} 0, & \text{if } V = 0 \\ \frac{C}{V}, & \text{otherwise} \end{cases}$$

B) LUMINOSITY ENHANCEMENT:

To enhance the luminosity and preserve the color, the R, G, and B channels should be adjusted by the same Proportion. Luminance gainmatrix G(x, y)which is defined as follow

$$\frac{r'(x,y)}{r(x,y)} = \frac{g'(x,y)}{g(x,y)} = \frac{b'(x,y)}{b(x,y)} = G(x,y)$$

To obtain the color-invariant luminance gain matrix, the color image is transformed into the HSV color space where theluminosity channel (V) is decoupled from the two colorcomponents, hue (H) and saturation (S)[26][27]. The H and S channels are irrelevant to luminance, and both are ignored. The luminance intensity of a pixel at the (x, y) position is obtained as the maximum (max) of the R, G, and B values. Therefore, the luminance gain matrix can be inferred as

$$G(x,y) = \frac{V'(x,y)}{V(x,y)} = \frac{V'(x,y)}{\max(r(x,y), g(x,y), b(x,y))}$$

From the V'(x, y)dynamic range of image is enhanced by Gamma correction, according to this formula

$$w = u^{\gamma}$$

Where u denotes the normalized pixel value of the luminosity channel, w is the normalized output, and γ is a constant.

C) CONTRAST ENHANCEMENT:

To further enhance the contrast of retinal images, the CLAHE method is applied. The CLAHE divides the image into small regions called tiles; the histogram on each tile is equalized so that local contrast is enhanced[26][27]. This local enhancement technique can result in noise dominating on individual local regions. Hence, a clip-limitation strategy is employed to prevent local [22] contrast from hitting the maximum. In our method, the number of tiles is 8×8, and the clip limit is 0.01. For color retinal images, it is better to implement CLAHE on the luminosity channel to reduce color distortion. This contrast enhancement will only operate on the luminosity channel and can avoid the gamut problem. Thus, the retinal image in RGB color space by luminosity enhancement is converted into L*a*b* color space[24][25]. The CLAHE is used to enhance the L channel. Then the processed image in the L*a*b* color space is transformed back into the RGB color space as shown in fig 7.

V.IMPLEMENTATION AND RESULTS

A) CHANNEL SPLITING

The conversion from RGB color space to LAB and HSV color space is governed by following formula.

$$M = \max(R, G, B)$$
$$m = \min(R, G, B)$$
$$C = M - m$$

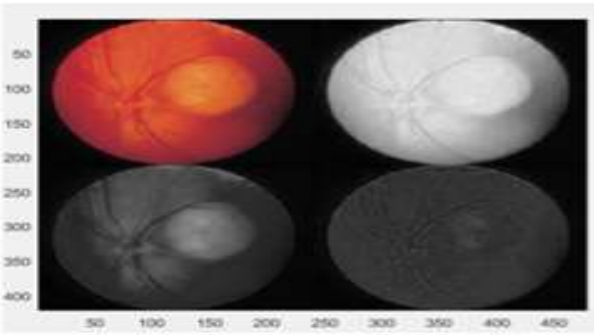
$$H' = \begin{cases} \text{undefined}, & \text{if } C = 0 \\ \frac{G-B}{C} \mod 6, & \text{if } M = R \\ \frac{B-R}{C} + 2, & \text{if } M = G \\ \frac{R-G}{C} + 4, & \text{if } M = B \end{cases}$$

$$H = 60^\circ \times H'$$

$$V = M$$

$$S_{HSV} = \begin{cases} 0, & \text{if } V = 0 \\ \frac{C}{V}, & \text{otherwise} \end{cases}$$

The channel splitting is shown in the figure 2



A. CHANNEL SPLITTING

Fig.1. Channel splitting

B) LUMINOSITY ENHANCEMENT USING CLAHE ALGORITHM

To obtain the color-invariant luminance gain matrix, the color image is transformed into the HSV color space where the luminosity channel (V) is decoupled from the two color components, hue (H) and saturation (S). The H and S channels are irrelevant to luminance, and both are ignored. The luminance intensity of a pixel at the (x, y) position is obtained as the maximum (max) of the R, G, and B values. Therefore, the luminance gain matrix can be inferred as

$$G(x,y) = \frac{V'(x,y)}{V(x,y)} = \frac{V'(x,y)}{\max(r(x,y), g(x,y), b(x,y))}$$

From the V'(x, y) dynamic range of image is enhanced by Gamma correction , according to this formula

$$w = u^{\gamma}$$

where u denotes the normalized pixel value of the luminosity channel, w is the normalized output, and γ is a constant.

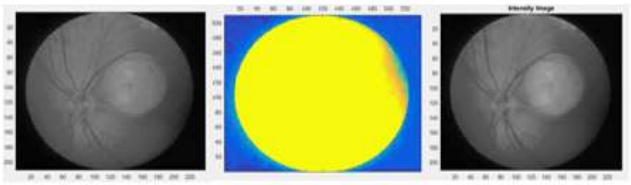


Fig.2.Before And After Histogram Equalization

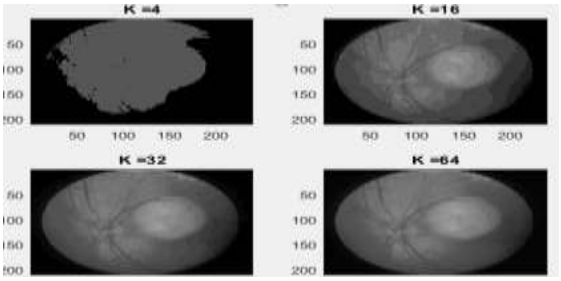


Fig.3.applying threshold values

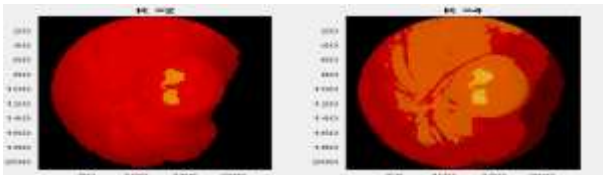


Fig.4.after applying threshold

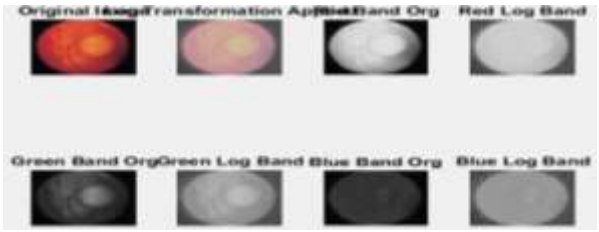


Fig.5.Rgb Bands

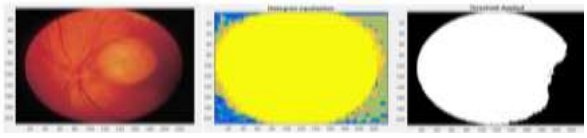


Fig.6.Transformation Image

Fig.7.Enhanced Image

VI. CONCLUSION

Here we present an effective method for color retinal image enhancement based on luminosity and contrast adjustment. First, the luminosity of the color retinal image is enhanced by a luminance gain matrix based on gamma correction, and then image contrast is enhanced by CLAHE in the L*a*b* colorspace. The performance of our proposed method was validated on two large color retinal image datasets. The results show that, compared with contrast enhancement in other color spaces and other methods, our proposed method achieves superior improvement of color retinal images, especially for those with initially of poor quality.This method is not only able to +6 enhance important anatomical structures of the retina, but italso preserves the naturalness of the images. This effective method of color retinal image enhancement will greatly assist ophthalmologists in disease diagnosis through retinal image analysis, and will be greatly beneficial to automated image analysis systems. The clinical evaluation of our method is currently in progress

VII. REFERENCES

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