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Diabetic Retinopathy Image Enhancement using Vessel Extraction in Retinal Fundus Images by programming in Raspberry Pi Controller Board

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Abstract: *Diabetic retinopathy is one of the leading complication of diabetes and also one of the leading preventable blindness. Early diagnosis and treatment may prevent such condition or in other words, annoyance of the disease may be overcome. The fundus images produced by automated fundus camera are often noisy making it difficult for doctors to precisely detect the abnormalities in fundus images. In the present paper, we propose to use vessel extraction of Retinal image enhancement and implemented in Raspberry Pi board using opencv library for faster execution and cost effective processing unit which helps during mass screening of diabetic retinopathy. The effectiveness of the proposed techniques is evaluated using different metrics and Micro-aneurysms. Finally, a considerable improvement in the enhancement of the Diabetic Retinopathy images is achieved.*

Keywords*:* Diabetic Retinopathy, Raspberry Pi Controller Board, Retinal Image enhancement.

INTRODUCTION

Diabetic Retinopathy (DR) is one of the most common eye diseases which occur due to diabetes mellitus. It damages the tiny blood vessels inside the retina resulting loss of vision. The risk of the disease increases with age and therefore, middle aged and older diabetics are prone to Diabetic Retinopathy [1].Color retinal fundus [2] images are used by ophthalmologists to study this disease. During mass screening, it is very important to clearly detect and distinguish the blood leakages, haemorrhages and lesions amongst the numerous blood vessels present in eye [1]. Micro-aneurysms are small swellings which generates on the side of the tiny blood vessels in the retina. These swellings may rupture and allow blood to leak into the nearby tissue. The size of a typical micro-aneurysm is from 20-200 micron [3].Regarding the enhancement of retinal images few studies have been published yet now. Diabetic Retinopathy Image Enhancement using CLAHE by Programming TMS320C6416 is proposed by Srinivasan A et al [4].Retinal image enhancement using curvelet is proposed by Candes et al [5]. Miri et al [6] used multi-resolution tools using a non-linear function for modifying the curvelet coefficients. This techniques is based on matched filtering in enhancing low contrast blood vessels over a limited area but the computation becomes complex with image size [7, 8]. Piezeret al. [9] uses Adaptive Histogram Equalization (AHE) to overcome the drawbacks of Histogram Equalization, especially for images with varying contrast. They explained the diagnostic capability of AHE on chest CT scan.

Region-growing [10] algorithm fully delineates each marked object and subsequent analysis of the size, shape, and energy characteristics of each candidate results in the final segmentation of micro-aneurysms. While this is a significant improvement, the region growing algorithm remains sub optimal. Kim et al. [11] used brightness preserving bi histogram equalization to overcome the drawback of changing brightness of an image. It is being observed that in most of their studies, they implemented their work in PC based simulation software. The idea behind the present work is to exploit the effectiveness of blood vessel extraction as an early detection of retinopathy and also finding out the micro-aneurysms of diabetic patients and implementing in real time system like

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raspberry pi controller board to avoid the PC based simulation.

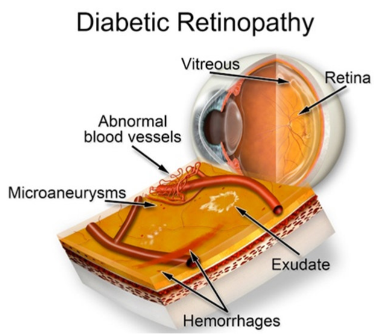

Fig.1. Diabetic Retinopathy effected Eye.

APPROACH

Proposed algorithm in Raspberry Pi controller board. Fig 2 shows the schematic view of our proposed method. Opencv Library is used with C++ language for programming.

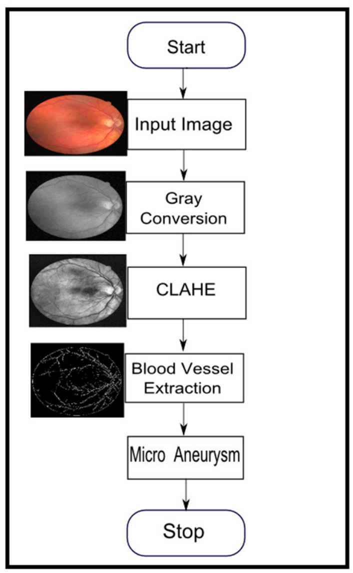

Fig.2. Flow chart of the proposed method.

IMAGE ENHANSMENT TECHNIQUE

The flow chart of the proposed approach is shown in Fig 2. It loads a retinal color image as a input image and after that it will convert this RGB image to Gray scale image. This algorithm is tried to find out the micro-aneurysms after the said enhancement techniques and also tries to find The Absolute Mean Brightness Error (AMBE), Peak Signal to Noise Ratio (PSNR).

Preprocessing

Loaded input image, I, has to be first converted to a gray scale image. Let J is the said gray scale image, and R, G, B be the three color channels of the image I . Classically, the gray-scale image J is obtained by a linearly weighted transformation:

$$J(x; y) = \alpha.R(x; y) + \beta.\ G(x; y) + \gamma.B(x; y) \ldots\ldots\ldots\ldots\ldots (1)$$

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Where α, β and γ are the weights corresponding to the three color channels, R, G, and B, respectively, and $(x; y)$ are the pixel location in the input image. The most popular method selects the values of α, β and γ by eliminating the hue and saturation information while retaining the luminance. To this end, a color pixel is first transformed to the so-called NTSC color space from the RGB space by the standard NTSC conversion formula:

$$\begin{bmatrix} \mathbf{Y}(x,y) \\ \mathbf{I}(x,y) \\ \mathbf{Q}(x,y) \end{bmatrix} = \begin{bmatrix} 0.299 & 0.587 & 0.114 \\ 0.596 & -0.274 & -0.322 \\ 0.211 & -0.523 & 0.312 \end{bmatrix} \begin{bmatrix} \mathbf{R}(x,y) \\ \mathbf{G}(x,y) \\ \mathbf{B}(x,y) \end{bmatrix} \quad \ldots\ldots(2)$$

where Y, I and Q represents the NTSC luminance, hue, and saturation components, respectively. Then the luminance is used as the gray-scale signal: $J(x; y) = Y(x; y)$. Thus we have $\alpha= 0{:}299;\beta=0{:}587;\ \gamma= 0{:}114{:}$

In this work, we research the RGB-to-gray conversion ofEq.1, which to the best knowledge of the authors, and attempt to find new values of (α,β,γ)which are optimal for our work. Our research results reveal that 1) to get a strong gray-scale image, one should select the values of (α,β,γ) that satisfy $\alpha>\beta>\gamma$2).

It is necessary to intensify the contrast of the image to provide a better processing for subsequent image analysis steps. Contrast Limited Adaptive Histogram Equalization [12] is a common pre-processing method for processing medical image, as it is very effective in making the region of interest more visible. This method is formulated based on dividing the image into several non-overlapping regions of almost equal sizes. Local histogram equalization is performed at every disjoint region. To eliminate the boundaries between the regions, a bilinear interpolation has also been applied. In this stage, only the gray levels processed because MAs appear with highest contrast in this particular channel [13].

Blood Vessel Extraction

The segmentation of retinal blood vessels is done by a thresholding method proposed by Saleh et al [14]. From the pre-processed fundus image the background exclusion is performed by subtracting the original intensity image from the average filtered image so that the foreground objects may be more easily examined. Isodata technique is used to provide an automatic threshold in a binary image but this technique runs through number of iterations until the proper threshold value is achieved. So, in this proposed techniques local entropy thresholding [15] has been implemented. This process yields an optimum threshold value by choosing the pixel intensity from the images histogram that exhibits the maximum entropy over the whole image. Let h(i) be the value of a normalized histogram and it takes the integer values from 0 to 255. The normalized histogram can be expressed as

(1)

Entropy of white pixels is given by the following equation:

$H_w(t)= -$ (2)

Entropy of black pixels is given by the following equation:

$H_B(t)=-$ (3)

Optimal threshold value be selected by maximizing the entropy of black and white pixels

t= 0……..max (4)

The resulting binary is generated from the following form:

B(x,y)= (5)

Where h(x,y) is the background excluded image

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OUTPUT AND ANALYSIS

Nearly 55 DR images are tested with the proposed image enhancement techniques. The input images were taken from Messidor digital retinal database [17]. The Absolute Mean Brightness Error (AMBE) is calculated using the difference between original and enhanced image AMBE(X,Y)=|XMYM|, where XM is the mean of the input image and YM is the mean of the output image. Smaller value of AMBE indicates lesser loss of information during enhancement. Therefore in terms of AMBE, CLAHE gives the best result compared to Histogram equalization method as shown in the scatter plot of AMBE values in Fig. 3. A large value of Peak Signal to Noise Ratio (PSNR) indicates better contrast enhancement in the output image as shown in Fig 5. The PSNR is computed as follows:

Where MSE is termed as mean square error and it is defined as:

PSNR is used to evaluate the degree of contrast enhancement. Greater PSNR indicates better image quality. So, in terms of PSNR also CLAHE is showing the best result in the scatter plot shown in Fig 4.

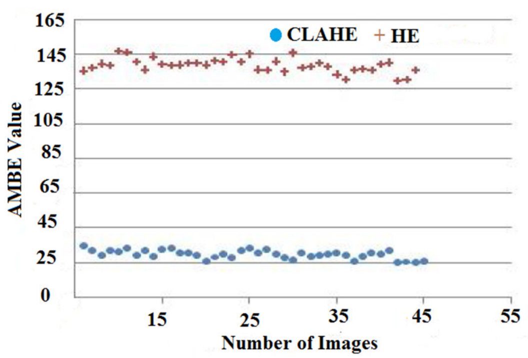

Fig.3. Scatter Plot of AMBE values of enhanced images

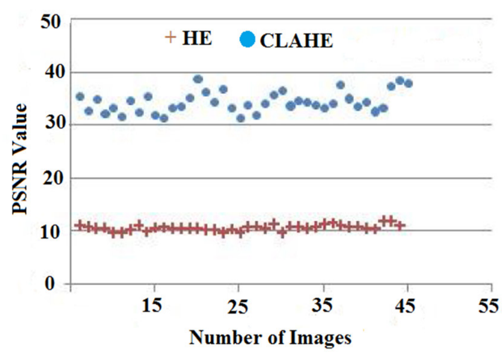

Fig.4. Scatter plot of PSNR values of enhanced images

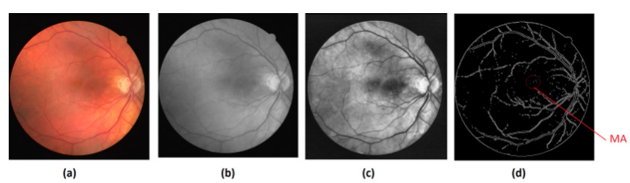

Fig.5. (a) RGB image (b) Gray level image (c) CLAHE
(d) Extracted blood Vessel with MA

Abbreviations and Acronyms

MA, AMBE, PSNR.

EXPERIMENTAL SETUP

The proposed method has been deployed in raspberry Pi controller board to ensure faster execution so that it will be helpful for mass screening of diabetic retinopathy.

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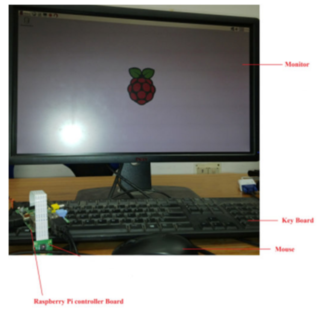

Fig.6. Experimental setup with Raspberry pi controller board

The raspberry pi controller board design is based on around a Broadcom BCM2835 SoC, which includes an ARM1176JZF-S 700MHz processor, Video Core IV GPU, and 512Mbytes of RAM with highly developer friendly Debian GNU/Linux operating system and Four USB port. A 4-pole 3.5mm stereo audio jack with composite video output and microSD, MMC, SDIO flash memory card slot is also attached with this board.

CONCLUSION

In this paper, a hardware based frame work of image enhancement has been presented. Number of DR images obtained from practical experiments has been presented. It is found from the experimental results that the proposed method performs better in terms of computation other than simulation based software. In our future work colour images will be taken using real time camera attached with raspberry pi controller board and new parameters will be considered for the evaluation of enhancement techniques.

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