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A Novel Technique for Fundus Image Contrast Enhancement

G.Tirupati*, B.Subba Rao**
[*] Faculty of Bio-Medical Engineering, GVP College of Engineering for Women, Visakhapatnam, India.
tirubme@gmail.com
[**] Faculty of Bio-Medical Engineering, GVP College of Engineering for Women, Visakhapatnam, India.
bhasurao@gmail.com

ABSTRACT

Digital fundus Image analysis plays a vital role in computer aided diagnosis of several disorders. Image acquired with fundus camera often have low grey level contrast and dynamic range .We present a new method for fundus image contrast enhancement using Discrete Wavelet Transform (DWT) and Singular Value Decomposition(SVD).The performance of this technique is better than conventional and state of the art-techniques. With the proposed method the given Fundus Image is decomposed into four frequency sub band images and Singular Value Decomposition applied on Low-Low subband Image, which determines the intensity information. Finally Image reconstructed using modified Low-Low subband coefficients and three high frequency sub band coefficients. The qualitative and quantitative performance of proposed technique is compared with those of conventional techniques such as General Histogram Equalization (GHE), Local Adaptive Histogram Equalization (AHE), Contrast Limited Adaptive Histogram Equalization (CLHE), Brightness Fuzzy Preserving Histogram Equalization (BPFHE) and Singular Value Equalization (SVE). The proposed method shows better results than other contrast Enhancement Techniques on low contrast and dynamic range fundus Images, which leads to give helpful for retinal segmentation.

Key words: Contrast Enhancement, Discrete Wavelet Transform ,Retinal Image, Singular Value Equalization.

I.INTRODUCTION

Medical Image processing tool is widely useful for diagnosis several diseases. Other hand, retinal imaging analysis is an area of medical Image processing for narrowing and non vascular features, such as haemorrhages, exudates, microaneuysms and others are vital indications for various disorders such as diabetes or hypertension. It is thus very important for doctors to able to clearly detect lesions of blood vessels and optic nerve present in the image. But retinal image acquired from fundus camera low contrast and dynamic range, which is not suitable for further segmentation. So it is necessary to increase the retinal image contrast, which is acquired from fundus cameraMany techniques have been proposed for enhancing low contrast images. Among them, Histogram Equalization [3], its simplicity and good performance on almost all types of images. Histogram Equalization is classified into two classes: Global Histogram Equalization (GHE) and Local Histogram Equalization (LHE).

Global Histogram Equalization (GHE), which uses Global Histogram over the whole input image as its transformation function. In retinal image area like optical disk and others are over brightened than others. Local Histogram Equalization [7], which uses Local Histogram, specified by window. But this approach is tedious as more computations are required. Other hand, Adaptive Histogram Equalization, which uses local image statics such as mean and variance. But it is also not producing good contrast images. To overcome the limitations of Histogram Equalization many other methods have been developed .Among the methods, Brightness preserving Fuzzy Histogram Equalization [4], in which image is fuzzified, modified and then defuzzified, but cannot produce the contrast as required. Contrast Limited Adaptive Histogram Equalization: Adaptive Histogram Equalization has disadvantage of enhance the noise so for improvement Contrast Limited Adaptive Histogram Equalization (CLHE) produce enhance the image and suppress the noise. On the other hand, Singular Value Decomposition [10] is one it is based on equalizing the Singular Value Decomposition information of image, another technique is Singular Value Decomposition along with Discrete wavelet transform, SVE is applied on frequency domain of image, then image reconstructed using IDWT. In this study, we present a method modified DWT-SVE using Histogram Equalized and Contrast Limited Adaptive Histogram Equalized Image. The performance of technique has been compared with that of GHE, ACE, CLHE, BPFHE, SVE and DWT- SVE. Proposed technique overcomes the limitation of other methods.

The test of the paper is organized as follows: proposed technique is detailed in section II. Results are given in section III. Concluding remarks are furnished in section IV.

2. PROPOSED METHOD

Wavelet theory is an extension of Fourier theory in many aspects and it is introduced as an alternative to the short-time Fourier transforms (STFT). In Fourier theory the signal is decomposed into sine's and cosine but, in wavelets the signal is projected on a set of wavelet functions. Fourier Transform would provide good resolution in frequency domain and wavelet would provide good resolution in both time and frequency domains. Although the wavelet theory was introduced as a mathematical tool in 1980's, it has been extensively used in image processing that provide a multi resolution decomposition of an image in a bi-orthogonal basis and results in a non-redundant image representation. The basis are called wavelets and these are functions generated by translation and dilation of mother wavelet. In wavelet analysis the signal is decomposed into scaled (dilated or expanded) and shifted (translated) versions of the chosen mother wavelet. The wavelet as its name implies as a small wave that grows and decays essentially in a limited time period. A wavelet to be a small wave, it has to satisfy two basic properties:

1) Time integral must be zero

$$\int_{-\infty}^{\infty} \psi(t)dt = 0 \qquad \text{and}$$

2) Square of wavelet integrated over time is unity

$$\int_{-\infty}^{\infty} \psi^2(t)dt = 1$$

Wavelets have been used quite frequently in image processing. Wavelet transform, it decompose the image into four subband images referred to as Low-Low(LL),Low-High(LH),High-Low(HL) and High-High(HH).The frequency components of those subband images cover the frequency components of original image. Low-Low subband image contains illumination and others contain details of image. So LL subband image is modified by applying the SVD.The proposed method explained as follows. Fundus Image(X) is parallel processed by GHE and CLHE then both of these images are transformed by Discrete Wavelet Transform (DWT).Wavelet Transform, wavelets are localized waves. They have their energy concentrated in time or space and suited for analyzing transient signals. The data to be analyzed is multiplied with wavelet function .continuous wavelet transform is given by equation where X(t) is data to be analyzed. Ψ(t) is mother wavelet or basis function .all the wavelet functions are derived from mother wavelet through translation(shifting) and dilation(compression).

$$Xwt\ (\tau, s) = \frac{1}{\sqrt{s}}\, X(t)\psi \frac{(t-\tau)}{s}\, dt \qquad (1)$$

Where τ=shifting parameter, s=scaling parameter.

Discrete Wavelet transform is sampled version of continuous wavelet transform and it is based on sub band coding is found to yield fast computation of wavelet transform. Discrete wavelet transform computed by successive low pass filtering and high pass filtering of data obtained. Singular Value Decomposition, Singular value based image equalized technique is based on equalizing the singular value matrix obtained by Singular Value Decomposition (SVD) of an image which can be interrupted as a matrix is written as follows

$$X = Ux\Sigma xVxT \qquad (2)$$

Where Ux and Vx are orthogonal square matrices and Σx contains sorted singular value on its main diagonal and contains intensity information. The equalized image cab be written as follows

$$Equalized = Uy\ (\xi\Sigma y)\ VyT \qquad (3)$$

Finally image is reconstructed using equalized LLy and three high frequency sub band images by applying IDWT. The illumination factor is calculated by using the following equation

$$\Xi = \max\ (\Sigma LLx)/\max\ (\Sigma LLy) \qquad (4)$$

Where LLx is a singular value matrix of GHE image and LLy is singular value matrix of CLHE image. Proposed algorithm as follows. Stage 1: Load Fundus Image (low contrast).Stage 2: Apply General Histogram Equalization (GHE) and Contrast Limited Histogram Equalization (CLHE) on stage 1 image. Stage 3: Implement Discrete Wavelet Transform (db.9/7, level-1)(DWT) on stage 2 images, which result get two set four sub band images. Stage 4: Singular Value Decomposition is applied on both Low frequency sub band images. Stage 5: Find illumination equalization factor ξ=max (Σx)/max (Σy).Stage 6: New approximation coefficients are generated using equalization factor (ξ) and approximations (LLy).Stage 7: Apply IDWT on new approximation coefficients and detail coefficients. Stage 8: Fundus Image with high contrast is obtained.

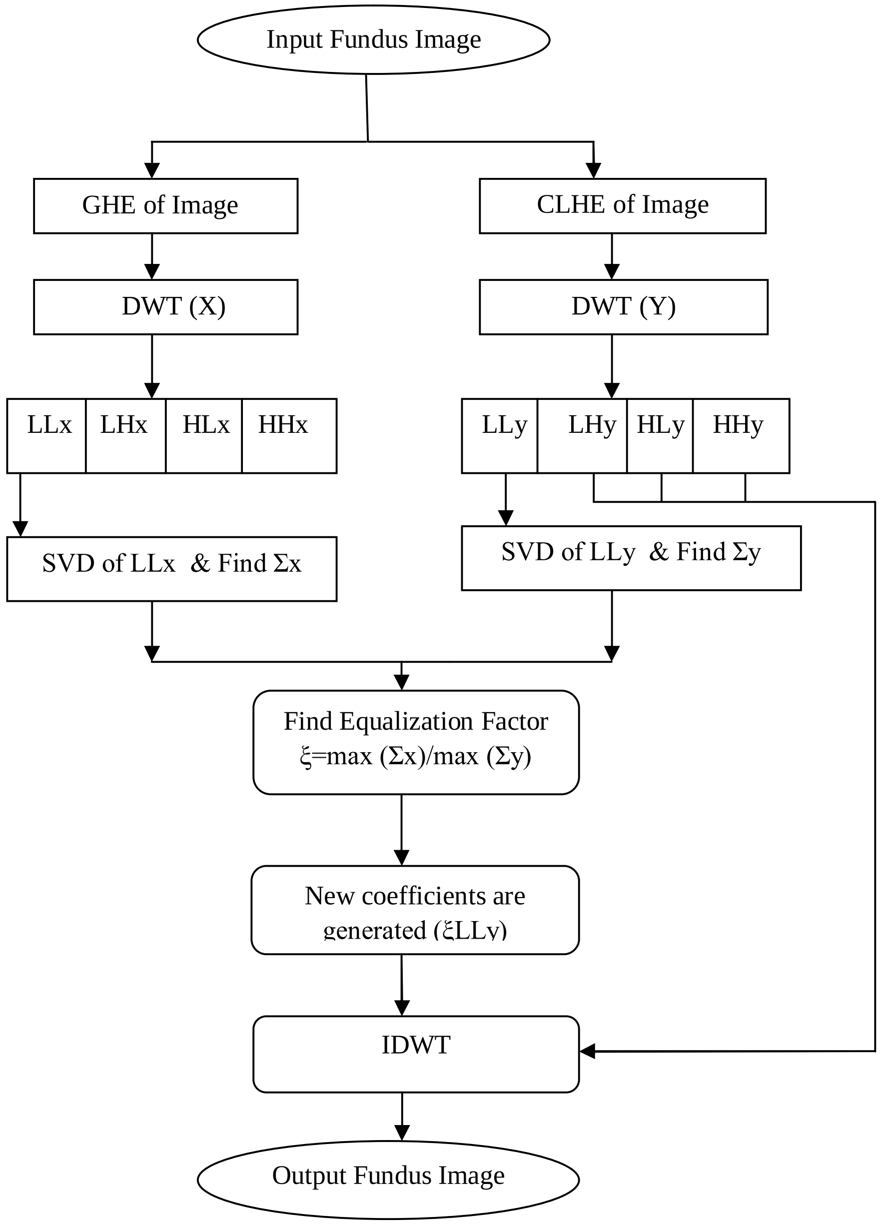

Figure 1. Block Diagram

3. RESULTS

Proposed technique is applied on green channel retinal image, figure 2 shows the all channels along with RGB image, which gives better contrast over other channels. Proposed algorithm implemented on retinal data base, which contains both normal (10 in no.) and abnormal (10 in no.) images. The resultant images show better in contrast and brightness as compared with state of art techniques. figure 3.(a) –figure 3.(f) show the normal retinal images using existed techniques and figure 3.(g) shows the proposed technique. We also verified the technique using objective evolution, in which entropy and dynamic range parameters are calculated. Entropy is used to measure the content of image, higher the value indicates richer the details. Dynamic range is indicator of contrast and how the good image is. So these two parameters show higher for the proposed technique. Table 1 and Table 2 show the both normal and abnormal retinal images entropy and dynamic range parameters.

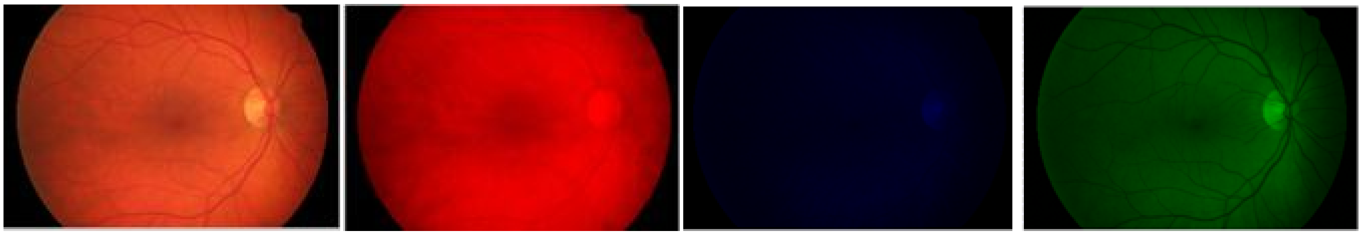

Figure 2. a) Retinal Image (RGB) b) Red Channel Image c) Blue Channel Image d) Green Channel Image

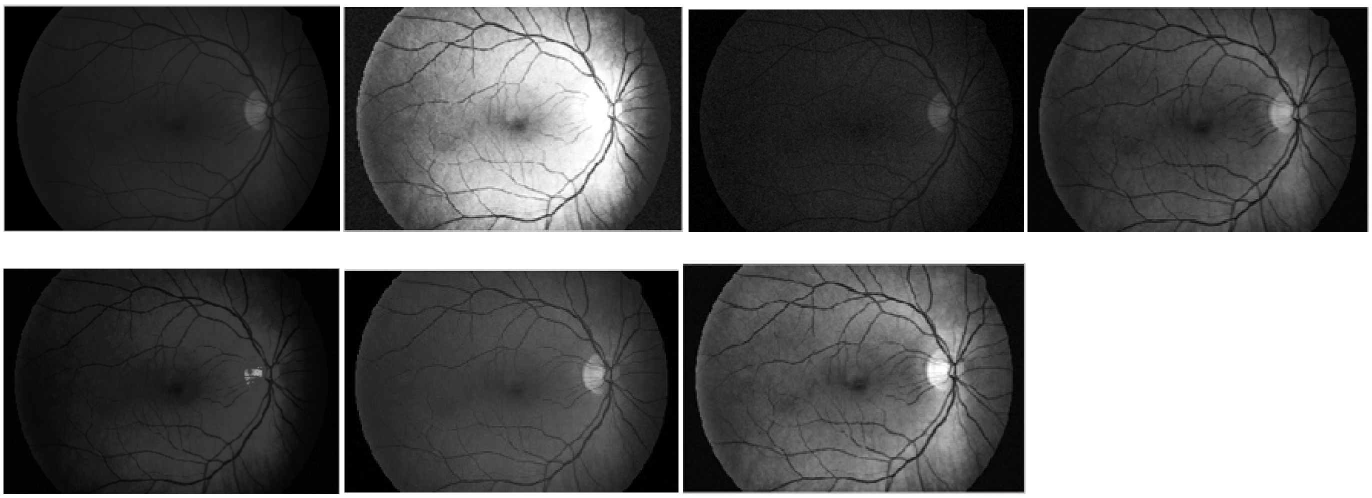

Figure 3. a) Green channel (Gray) b) GHE c) AHE d) CLHE e) BPFHE f) SVE g) DWT&SVD

Table 1. Entropy of Normal retinal images

Name of the Technique	Entropy									
	1h	2h	3h	4h	5h	6h	7h	8h	9h	10h
GHE	5.11	5.01	5.03	5.17	4.94	4.94	4.68	4.94	4.86	5.10
AHE	5.74	5.66	5.52	5.41	5.43	5.40	5.47	5.39	5.42	4.66
CLHE	6.38	6.34	6.28	6.36	6.14	6.20	6.12	6.13	6.10	6.16
BPFHE	5.10	4.8	5.01	5.02	4.82	4.78	4.99	4.88	4.75	5.51
SVE	5.37	5.27	5.27	5.3	5.12	5.06	5.19	5.08	5.06	5.28
DWT&SVD	**6.94**	**6.88**	**7.07**	**7.12**	**6.94**	**6.92**	**6.91**	**6.93**	**6.87**	**6.96**

Table 2.Entropy of abnormal retinal images

Name of the Technique	Entropy									
	1g	2g	3g	4g	5g	6g	7g	8g	9g	10g
GHE	4.65	4.70	4.64	4.69	4.82	4.80	4.90	4.86	4.88	5.18
AHE	5.25	5.24	5.37	5.35	5.30	5.36	5.45	5.50	5.39	5.75
CLHE	5.85	5.96	5.54	5.72	5.95	6.06	6.13	6.17	5.96	6.32
BPFHE	4.70	4.70	4.64	4.64	4.75	4.80	4.89	4.85	4.82	5.07
SVE	4.80	4.84	4.82	4.79	4.97	5.02	5.03	5.03	5.01	5.38
DWT&SVD	**6.75**	**6.78**	**6.45**	**6.57**	**6.88**	**6.99**	**6.86**	**6.77**	**6.79**	**6.81**

Table 3.Dyanamic Range of normal retinal images.

Name of the Technique	Dynamic Range									
	1h	2h	3h	4h	5h	6h	7h	8h	9h	10h
GHE	239	239	243	239	239	235	235	235	235	235
AHE	154	144	132	117	102	93	127	115	119	106
CLHE	209	218	202	206	177	163	215	198	216	162
BPFHE	152	181	158	148	175	194	180	186	172	171
SVE	228	207	255	245	192	168	238	229	218	195
DWT&SVD	**255**	**255**	**255**	**255**	**255**	**239**	**255**	**255**	**255**	**254**

Table 4. Dynamic Range of abnormal retinal images

Name of the Technique	Dynamic Range									
	1g	2g	3g	4g	5g	6g	7g	8g	9g	10g
GHE	243	239	239	239	239	239	239	239	235	235
AHE	108	96	102	106	65	97	118	117	98	133
CLHE	176	156	160	181	172	170	198	185	167	199
BPFHE	154	158	205	217	176	185	184	190	167	178
SVE	207	186	167	181	201	186	205	177	174	183
DWT&SVD	**255**	**252**	**255**	**255**	**255**	**255**	**255**	**249**	**255**	**255**

4. CONCLUSION

In this paper proposed Technique which gives better performance for further image processing such as segmentation and classification and comparisons on both subjective and objective indicated the superiority of this technique over the conventional methods. Objective evolution has been done by using Entropy and dynamic range, those shows higher values for this technique. We use entropy and dynamic range for evaluating the retinal image along these needs to find appropriate parameters for better evaluation.

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