CONTRAST ENHANCEMENTUSING NON-SUBSAMPLED CONTOURLET TRANSFORM WITH HISTOGRAM EQUALIZATION FOR ULTRASOUND IMAGES

T.Joel[1], J. Yogapriya[2]

1 Associate Professor, R.M.K. Engineering College 2. Programmer Analyst, Cognizant Technology Solutions

Abstract--**Enhancement of contrast in an image is a vital process of image processing, it increases the intensity of image pixels. By enhancing the contrast of an image, the quality of the image will be increased.The anticipatedtechniqueis the combination of non-subsampled contourlet transform and bilateral filter. The key contribution of this paper is the usage of a weighted mean separated sub-histogram equalization technique for increasing the contrast of medical ultrasound images. The performance of the proposed technique provides improved contrast enhancement features when related with the existing methods such as contourlet transform and Histogram Equalization in terms of structural similarity index matrix, PSNR and Absolute Mean Brightness Error.***

KeyWords: Bilateral filter, weighted mean separated sub-histogram equalization, non-subsampled contourlet transform, ultrasound image.

1. INTRODUCTION

Extracting data from the Medical ultrasound images need high quality images. The quality of an image is one of the major problems on information extraction with image.The contrast of image is an important factor on the quality of image. for increasing the contrast of image various techniques are designed in [2]. There also have a set of techniques on transform domain for enhancing the contrast, such as wavelet, curvelets, and contourlet transform [3][10]. These techniques calculate the coefficients for the input image and it is modified by using the mapping functions, after that it will be rebuild to obtain the enhanced image [4].

Histogram Equalization (HE) improves the contrast of numerous images, particularly while the functional information of the medical image is characterized by nearby contrast values [5-6]. The intensities of the histogram will be allocated with this adjustment. It makes to increase the contrast of pixel area available on the image with lower contrast. The main problem occurs in the transform-based technique such as contourlet transform is shift-variant. The presence of down-samplers and up-samplers in the Laplacian pyramid and the directional filter bank in contourlet transform [12], the transform isnot shift-invariant.By using the transform-based technique, there is possibility to loss some symmetrical information of image. This issue will be resolved by using the Non-subsampled Contourlet Transform (NSCT) [7].NSCT can deliver the smooth appearance of contours of image.Oneofthetechniquesof nonlinear filtering is Bilateralfilteringpresented by Tomasi et al. [1]. It introduces the concept of smoothing by weighting the filter coefficient with their component intensities. Spatial distance and the intensity distancedependupon weights of the pixels in local neighborhood.The proposed technique initially decomposes the input image by applying NSCT and generates several coefficients. These coefficients are filtered with Bilateral filter. Finally, Weighting Mean-Separated Sub-Histogram Equalization (WMSHE) is used to enhance the image contrast.

The rest of the work is organized as: section II describes the proposed method. Section III indicates the performance metrics. Section IV illustrates results and discussions. Section V includes conclusion and references.

2. PROPOSED METHOD

In our proposed system, initially on source image we are applying the Non sub-sampled Contourlet Transform (NSCT) for decomposing the image. While decomposing the image at different scales, the image can be decomposed into a set of contourlet coefficients with different spectral resolution having numerous sub bands. A non-linear Bilateral Filter (BF) is performed on different contourlet coefficients to smooth the edges. After this process, inverse NSCT is used for reconstructing the modified NSCT coefficients for enhanced image. Last stage of our work remains to equalize the histogram of an image for improve the contrast and it is done by using WMSHE (Weighting Mean-Separated Sub-Histogram Equalization).The proposed method is illustrated in Figure 1.

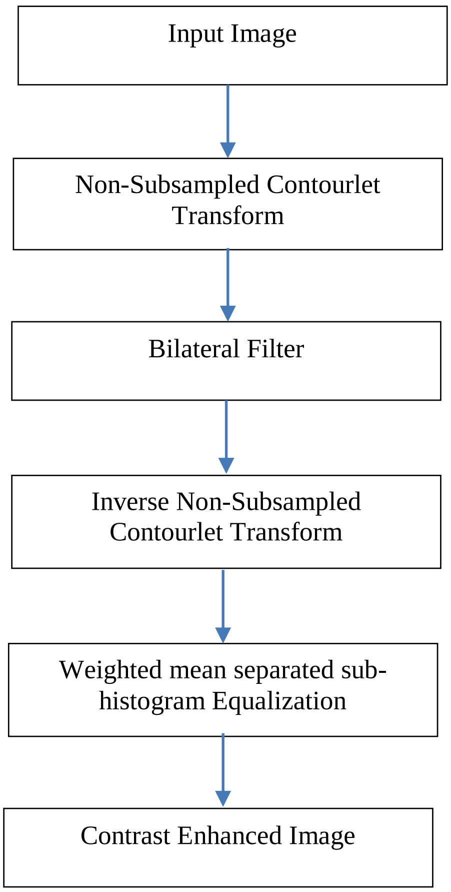

Figure 1 Functional diagram of proposed technique

A. NON-SUBSAMPLED CONTOURLET TRANSFORM

The main issue of contourlet transform is, it is not shift-invariance because of the presence of up and down sampling process in DFB and LP. The NSCT is designed to fix this issue, it includes non-subsampled pyramid (NSP) and non-subsampled directional filter bank (NSDFB) [7].Initially in the method, the NSP filters decompose the input image into low and high frequency components. On high frequency components, the NSDFB is executed [7].

B. BILATERALFILTERING

Tomasi and Manduchi [1] presented the Bilateral Filter. It is performed by the combination of two gaussian filters. Firstgaussian filter works in intensity domain whereas the secondgaussian filter works in spatial domain. The output is a weighted average of the input as it is a non-linear filter. The bilateral filter output for a pixel is defined as follows for an ultrasound image.

$$J_s = \frac{1}{K(s)} \sum_{p \in \Omega} (p-s) g(I_p - I_s) I_p$$

where K(S) is a normalization term.

$$K(s) = \sum_{p \in \Omega} f(p-s) g(I_p - I_s)$$

where g uses a gaussian filter in the intensity domain thatsymbolizes the range filterandf uses a gaussian filter in the spatial domain which indicates the domain filter.

Mathematically domain filtering can be expressed as:

$$J_s = \frac{1}{K(s)} \sum_{p \in \Omega} (p-s) g(I_p - I_s) I_p$$

where

$$f(p-s) = exp^{-\frac{\|p-s\|^2}{2\sigma d^2}}$$

f(p-s) measures the spatial closeness between theneighborhoodcenterandtheadjacentpoint.

Range filtering is defined as follows

$$J(s) = \frac{1}{k_r(s)} \sum_{p \in \Omega} g(I_p - I_s) I_p$$

where

The photometric similarity between the center pixel and its adjacent point p is measured by g(Ip-Is).

$$g(I_p - I_s) = exp^{-\frac{\|Ip-Is\|^2}{2\sigma d^2}}$$

Normalized constant in this case is

$$K_r(s) = \sum_{p\in\Omega} g(I_p - I_s)$$

C. WEIGHTED MEAN SEPARATED SUB-HISTOGRAM EQUALIZATION

Weighted mean separated sub-histogram equalization method performs a separation of histogram based on weighting mean function [9] and equalizing sub-histograms for contrast enhancement.

3. PERFORMANCE METRICS

To show improvement in contrast enhancementvarious parameters are measured in terms of structural similarity index matrix (SSIM), PSNR and Absolute Mean Brightness Error (AMBE). SSIM ismainly used for checking similarity between original and filtered images.

$$SSIM = \frac{\left(2\,\bar{X}\bar{Y} + k_1\right)\left(2\sigma_{XY} + k_2\right)}{\left(\left(\bar{X} + \bar{Y}\right)\right)\left(\sigma_X{}^2 + \sigma_Y{}^2\right)}$$

Where $k_1 = L^2 C_1$

$k_2 = L^2 C_2$

L is the active range of the pixels and the value of C_1 and C_2 should be greater than one.

PSNR is defined as

$$PSNR = 10\ log_{10}\left(\frac{255^2}{MSE}\right)$$

Absolute Mean Brightness Error is a system of measurement that measure the brightness protection. A lower value of Absolute mean brightness errorindicates a mean brightness of enhanced image nearer to the original image. It is calculated as follows:

$$AMBE = s(x,y)_{mean} - t(x,y)_{mean}$$

Where $s(x,y)_{mean}$ is the mean of original image $s(x,y)$and $t(x,y)_{mean}$ is the mean of the enhanced image in contrast $t(x,y)$.

4. RESULTS AND DISCUSSION

Herein we performed fewsystems of measurement to test the performance of the proposedtechniquewithclinical ultrasound images.

Improvement of contrast enhancement are compared with Histogram Equalization (HE), contourlet transform, Contrast Limited Adaptive Histogram Equalization (CLAHE)and the proposed method of non-subsampled contourlet transform with Histogram Equalization.

The result analysisis done by determiningthe three parameters [SSIM,Peak signal to Noise Ratio, AMBE]. The underlying tables shows performance analysis for various methods for ultrasound images.

Table 1:SSIM obtained for different methods

Ultrasound Images	Contourlet	HE	CLAHE	Proposed Method
Cardiac	0.581	0.004	0.244	0.998
Kidney	0.524	0.001	0.164	0.998
Thyroid	0.458	0.002	0.140	0.997

Table 2: PSNR obtained for different methods

Ultrasound Images	Contourlet	HE	CLAHE	Proposed Method
Cardiac	25.14	12.06	12.06	**44.23**
Kidney	24.93	14.15	14.15	**42.33**
Thyroid	24.98	14.20	14.20	**43.02**

Table 3: AMBE obtained for different methods

Ultrasound Images	Contourlet	HE	CLAHE	Proposed Method
Cardiac	0.0008	0.0005	0.0005	**0.0001**
Kidney	0.0008	0.0003	0.0003	**0.0002**
Thyroid	0.0009	0.0004	0.0004	**0.0001**

The performance of the proposed method was evaluated using SSIM, PSNR and AMBE. The image which is given as an input is a cardiac ultrasound medical image and contrast enhancement was performed using the proposed technique and compared with Histogram Equalization,contourlet transform, and CLAHE.Table 1 shows SSIMestimate of the proposed techniqueis improved when performed withHistogram Equalization, contourlet transformand CLAHE.Three different images such as cardiac, kidney and thyroid ultrasound images has been taken into consideration. Table 2 shows Peak Signal to Noise Ratio values, which designates the plannednon-subsampled contourlet transform with Histogram Equalization technique shows advancement when performed with the existingmethods. Table 3specifiesAMBE values, which shows the performance of the proposed non-subsampled contourlet transform with bilateral filter method is better thanHistogram Equalization, contourlet transform and CLAHE.

Figure2illustratestheinputultrasound cardiac image. The output image of contourlet transform is shown in Figure 3. The output images of AE and CLAHE are shown in Figures 4 and 5 respectively. Figure 6 shows the output of the proposed non-subsampled contourlet transform with bilateral filter method. The contrast enhanced image of the proposed method is visually pleasing when compared to the other existing methods.

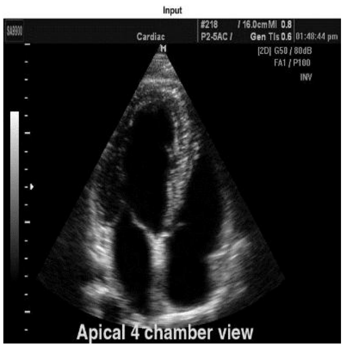

Figure 2: Input ultrasound cardiac image

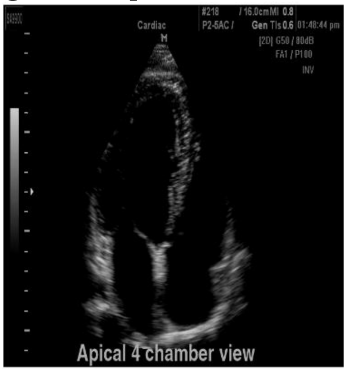

Figure 3: Contourlet Transform

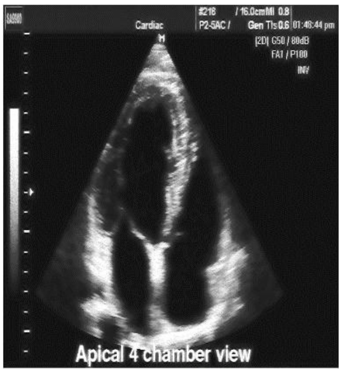

Figure 4 :HE

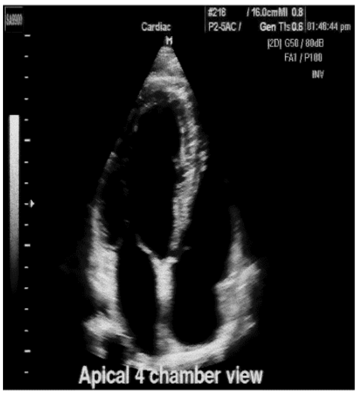

Figure 5: CLAHE

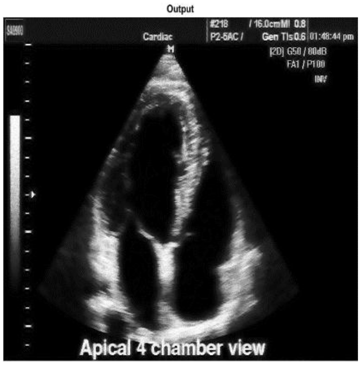

Figure 6: Output of proposed system

5. CONCLUSION

In this article, we introduced a technique for enhancing the medical ultrasound cardiac, kidney and thyroid images based on NSCT withHistogram Equalization. The technique WMSHE used NSCT for decomposing the image, bilateral filter for smoothing the edges present in the coefficients, WMSHE is processed for getting the enhanced image. WMSHE enhance the contrast by splitting the histogram of the image. The proposed technique indicates better performance than other existing systems. Implementation was done on MATLAB and the execution of our technique is compared with the performance of current techniques by using several metrics like, SSIM, PSNR and AMBE. On our future work, we planned to improve the proposed technique with this same method or may improve the contrast enhancement process of our work with some other methods that are best on that period.

6. REFERENCES

1. Tomasi,c., and Manduchi,R.:''Bilateal filtering for gray and color images'. IEEE Int.conf. On computer vision, Bombay, India,1998.

2. Sonia H. Contreras Ortiz et al, "Ultrasound image enhancement: A review," Biomedical Signal Processing and Control 7 (2012), 419–428.

3. Zong, X., Laine, A.F. and Geiser, E.A., 1998. Speckle reduction and contrast enhancement of echocardiograms via multiscale nonlinear processing. IEEE transactions on medical imaging, 17(4), pp.532-

540.

4. J. Starck, F. Murtagh, E. J. Candès, and D. L. Donoho, "Gray and Color Image Contrast Enhancement by the Curvelet Transform", IEEE Transactions On Image Processing, Vol. 12, NO. 6, 2003, pp. 706-717.

5. T. K. Kim, J. K. Paik and B. S. Kang, "Contrast Enhancement System Using Spatially Adaptive Histogram Equalization with Temporal Filtering", Journal: IEEE Transactions on Consumer Electronics, Vol. 44, No. 1, 1998, pp 82-87.

6. A. M. Reza, "Realization of the Contrast Limited Adaptive HistogramEqualization (CLAHE) for Real-Time Image Enhancement", Journal of VLSI Signal Processing 38, Kluwer Academic Publishers. Manufactured in The Netherlands, 2004, pp.35-44.

7. J. Zhou, L Cunha and Minh N. Do. Nonsubsampled contourlet transform: Construction and Application in Enhancement, IEEEInternational Conference on Image Processing, 2005.

8. Zong, X., Laine, A.F. and Geiser, E.A., 1998. Speckle reduction and contrast enhancement of echocardiograms via multiscale nonlinear processing. IEEE transactions on medical imaging, 17(4), pp.532-540.

9. P C Wu, F C Cheng and Y K Chen, A weighting mean separated Sub-Histogram Equalization for Contrast Enhancement, IEEE International conference on Biomedical Engineering and Computer Science, April 2010

10. T.Joel and R.Sivakumar, "An extensive review on Despeckling of medical ultrasound images using various transformation techniques", Applied Acoustics, Volume 138, pp 18-27, 2018.

11.Prabu, S., V. Balamurugan, and **K. Vengatesan**. "Design of cognitive image filters for suppression of noise level in medical images." Measurement 141 (**2019**): 296-301.

12. Garima Yadav, S Maheshwari and Anjali Agarwal, Contrast limited adaptive histogram equalization based enhancement for real time video system, IEEE International conference on Advances in Computing, Communications and Informatics, September 2014.

13. Kumar, V.D.A., Kumar, V.D.A., Malathi, S, Vengatesan.K,Ramakrishnan.M "Facial Recognition System for Suspect Identification Using a Surveillance Camera" Pattern Recognition and Image Analysis ,July 2018, Volume 28, Issue 3, pp 410–420

14. M. N. Do and M. Vetterli, "Contoulets: A directional multiresolution image representation," in Proc. IEEE Int. Conference on Image Processing, New York, USA, Sep. 2002, pp. 357-360.