

An Efficient Approach for Contrast Enhancement of Medical Image Using Dual Tree Complex Wavelet with High Pass Filter

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ABSTRACT- Image processing is extensively used area for the research and this is used for various applications such as remote sensing image data, medical image and weather forecasting etc. In this we are mainly focusing on medical image data and to get enhance quality of medical image becomes very challenging task nowadays. The low contrast medical image is very critical to analyze and obtain false results from such image. A lot of techniques have been developed to improve the quality of image. In this paper, we propose Dual Tree Complex Wavelet Transform (DTCWT) with High Boost Filtering to improve the quality of medical image. Here first method is used for enhancing the contrast of image and subsequent filtering technique is used for sharpening or eliminating the noise and blur from the image. The simulation of our proposed method is done using the MATLAB2012a simulator which comprises several functions for image simulation and the comparative analysis of our methodology uses performance measuring metrics such as PSNR and MSE. The experimental results of our methodology give improved quality of image than the existing approach.

Keywords- Image processing; Medical image; DTCWT; MATLAB; PSNR; MSE; MAE

INTRODUCTION

In digital image processing, it deals with increasing a digital system that acts upon operations on a digital image. The image is not anything further than a two dimensional signal. It has been defined by the geometric function $f(x, y)$ in which x and y are horizontally and vertically co-ordinates of the image and the amplitude of f at any couple of coordinate (x, y) is labeled the intensity or gray level of the image at that position. This is used for many applications such as Gamma ray imaging, X-ray, microwave band and ultraviolet band etc. In medical application, low contrast image analysis is a challenging predicament [1]. The low contrast digital image decreases the aptitude of spectator in analyzing the image. Histogram based methods are used to augment contrast of every type of medical images. They are chiefly used for all categories of medical images such as for Miasmammogram images, these methods are used to discover precise localities of cancerous regions and for low-dose CT images, these methods are used to overstate inconsequential anatomies analogous to containers, lungs nodules, airways and pulmonary fissures. The most effective method used for contrast augmentation is Histogram Equalization (HE). Image enrichment is principally humanizing the interpretability or sensitivity of information in images for human spectators and provided that `healthier contribution for other automated image processing techniques. The foremost intention of image enhancement is to transform aspects of an image to formulate it more appropriate for a specified task and a precise spectator. During this progression, one or more aspects of the image are personalized. The selection of aspects and the way they are personalized are detailed to a given task. Furthermore, spectator-specific factors, for instance the human visual system and the spectator's understanding, will commence an enormous covenant of subjectivity into the alternative of image enhancement methods. There subsist a lot of techniques that can augment a digital image lacking of blemishing it. The enhancement techniques can largely be divided in to the following two classes:

1. Spatial Domain Methods
2. Frequency Domain Methods

Basically in spatial domain the value of pixel strength are operated directly as equation given below:

$$G(x, y) = T [f(x, y)] \dots \dots \dots (1)$$

In frequency domain technique, the image is former transmitted in to frequency domain [2]. This means that, the Fourier transform of the image is calculated formerly. The overall enhancement operations are performed on the Fourier transform of the image and after that the Inverse Fourier transform is act upon to obtain the resultant image. These improvement functions are performed in order to

transform the image brightness, contrast or the allocation of the grey levels. As a consequence, the pixel value (intensity) of the resultant image will be customized according to the transformation function operated on the input values. In the frequency domain the image development can be done according to this equation:

$$G(u, v) = H(u, v) * F(u, v) \dots \dots \dots (2)$$

Where $F(u, v)$ is input image, $G(u, v)$ is improved image, and $H(u, v)$ is the transfer function. Image enhancement basically represents that transforming an image f into image g using T . (Where T is the transformation. The values of pixels in images f and g are nominated by r and s , correspondingly. Seeing that said, the pixel values r and s are associated by the expression

$$s = T(r) \dots \dots \dots (3)$$

Where T is a conversion that maps a pixel value R into a pixel value S . The outcomes of this transformation are mapped into the grey scale range while we are relating here simply with grey scale digital images. I will consider simply gray level images. A digital gray image should have pixel values in the range of 0 to 255. In this, we uses wavelet transform based approach to develop the excellence of medical image also diminish the noise and blur of the image using filtering technique (high boost filtering). This paper is arranged in such way: In section II presents the review of literature of earlier work done in medical image enhancement. In section III discuss our proposed methodology with its flowchart and section IV shows experimental results and analysis of our methodology. Last but not least, this section presents overall conclusion of this paper with its future work scope.

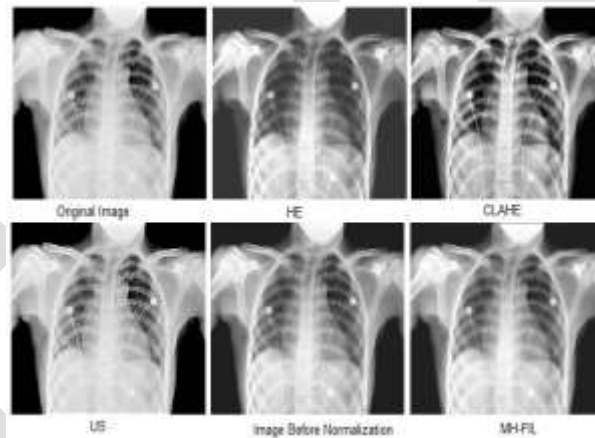


Figure1: Image enhancement process using Histogram Equalization

RELATED WORK

The area of medical image enhancement is the significant characteristic of medical image processing, as of their mammoth applications in several areas of our live particularly in the medical diseases diagnosis. Lots of articles and literature evaluation are published in this area and we will enlighten some of these works.

In 2014, **Subir Singh Lamba et al. [9]** proposed a novel MH-FIL for medical images. This method used two step of processing, in primary step global contrast of image is improved using histogram amendment followed by histogram equalization and then in subsequently step homomorphic filtering is used for image sharpening, this filtering if followed by image normalization. To estimate the effectiveness of their method they preferred two extensively used metrics absolute mean brightness error (AMBE) and entropy. Based on consequences of these two metrics this algorithm is confirmed as a bendable in use and effectual way for medical image enhancement and can be used as a pre-processing step for medical image understanding and investigation.

In 2013, **Qasima Abbas Kazmi et al. [8]** presented the specified process to oversimplify the diffusion procedure further into forward-and-backward progression. Additionally, the Forward - and Backward diffusion process could once more be used in perfection of the resolution of the given image. A particular image is being used for improvement of resolution of that image by means of interpolation and a forward-and-backward non-linear diffusion post-processing presents suppression of ringing. Process was initiated to be

extremely productive in distinctive those medical images which gives analogous images for two or more hazardous diseases. The process compliments the boundaries among the edges.

In 2013, **Rajesh Nema et al. [10]** proposed a system to get better the eminence of image using Kernel Padding and DWT with Image Fusion that augmented the contrast of Images that has varying intensity allocation predominantly satellite images, sustains the brightness of images, sharpens the edges and eradicates the blurriness of images. Primarily this is a pixel based edge guided image fusion procedure. In this system LL sub band of Image DWT is routed by contrast enhancement section where based on image brilliance level image is decomposed in dissimilar layers and then each & every layer intensity is stressed or compressed by engendering intensity transformation function. The partitioned intensity layers are too processed by canny edge recognition method as all the satellite images incorporates the noise due to atmospheric turbulence and this is Gaussian by character. The Canny edge detector is the preeminent method for detecting edges of image in the subsistence of Gaussian noise. Finally the contrast enhanced images are amalgamated according to the weight map concluded by edge map of image.

In 2012, **Uma Maheswari et al. [4]** presented a hybrid method to recover the image Excellency of Digital Imaging and communications in medicine (DICOM) images. The proposal of image enhancement technique is to advance the eminence of an image for early diagnosis. Subsequently, followed by a noise diminution using speckle diminution anisotropic filter. They suggested that the use of contrast enhancement method as an attempted to transform the intensity allocation of the image and to lessen the multiplicative noise. The performance of the proposed method is compared with the existing conventional algorithm and real time medical diagnosis image.

In 2012, **Yuanfeng Jin et al. [5]** this paper concerned regarding the applications of the partial differential equation (PDE) in image refurbishment and image enhancement. They primarily analyzed conventional methods of image investigation, study applications of the diverse method and diffusion equations in image refurbishment, as well as their enhanced algorithm for image enhancement.

In 2012, **S.M. Chao et al. [6]** Presented the customized method that considers also the incongruity of the brightness levels in a local neighborhood around each pixel was offered. On the other hand, the predicament of the automatic assessment of the decisive parameters was not addressed. A modified diffusion method, appropriate for images with low-contrast and jagged illumination, was portrayed in [7].

In 2010, **Ovidiu Ghita et al. [3]** concerned with the introduction of a novel gradient vector flow (GVF) field formulation that illustrates increased robustness in the presence of assorted noise and with its estimation when incorporated in the improvement of image enhancement algorithms. In this observation, the foremost contribution associated with this work exists in the enlargement of an adaptive image enhancement structure that couples the anisotropic dispersion models through the adaptive median filtering that is premeditated for the reinstatement of digital images corrupted with miscellaneous noise. To further exemplify the advantages allied with the anticipated GVF field formulation, additional experiments are conducted when the proposed approach is functioned in the creation of anisotropic models for texture enhancement

PROPOSED WORK

In this section, we briefly discuss about our proposed methodology to enhance the brightness, contrast and sharpening the images

Discrete Wavelet Transform

The CWT performs a multi-resolution analysis by retrenchment and dilatation of the wavelet functions. The discrete wavelet transform employs filter banks for the construction of the multi-resolution time frequency plane. The DWT [11] employs multi-resolution filter banks and individual wavelet filters for the analysis and reconstruction of signals. In many image processing applications wavelets plays an important role. In 2-D wavelet decomposition of an image, the 1-D discrete wavelet transform (DWT) is applying along the rows of image and after that results are decomposed along the columns. The results of this operation gives four decomposed sub band images that are low-high (LH), low-low (LL), high-high (HH) and high-low (HL). The absolute frequency spectrum of the input image is covered by frequency components of all these sub-

bands cover the complete frequency spectrum of the original image.

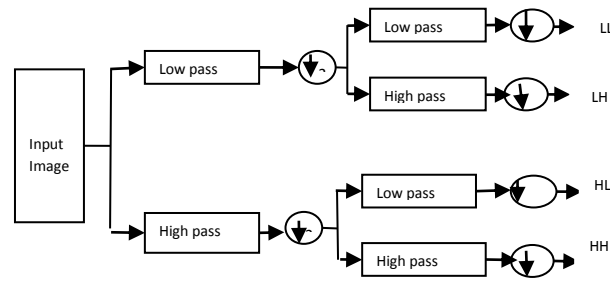


Figure 2: Decomposition of image using DWT

Dual Tree Complex Wavelet Transform (DT-CWT)

The DTCWT [12] is a comparatively modern enhancement to the discrete wavelet transform (DWT), with significant supplementary properties like; it is just about shift invariant and directionally discriminating in two and higher dimensions. It accomplishes this with a redundancy factor of only for 2-dimensional signals, which is considerably lower than the undecimated DWT. The multi-dimensional (M-D) dual-tree CWT is non-separable. It is based on a computationally proficient, distinguishable filter bank (FB). DT-CWT determines the complex transform of a signal using two split DWT decompositions (tree a and tree b). It is shown in Fig. 3. If the filters used in one are particularly designed dissimilar from those in the other it is promising for one DWT to fabricate the real coefficients and the other the imaginary. This redundancy of the two offers superfluous information for analysis but at the disbursement of extra computational power. It also supplies estimated shift-invariance (unlike the DWT). It agrees to perfect reconstruction of the signal. The Dual Tree Complex Wavelet Transform (DTCWT) has been anticipated to de-noise the ultrasound images.

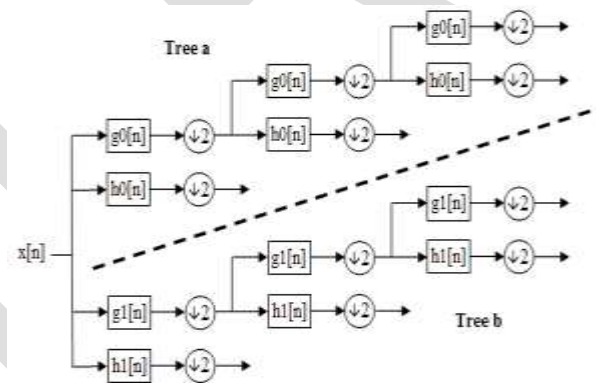


Figure 3: Tree structure diagram of DTCWT

Kernel Filtering

It initial defines a universal linear translation-variant filtering procedure, which engrosses a guidance image I, an input image p, and output image q. Both I and p are given beforehand according to the application, and they can be indistinguishable [14]. The filtering output at a pixel I is expressed as a weighted average:-

$$q_i = \sum_j w_{ij}(p)p_j \dots \dots \dots (4)$$

In this eqn. “i” and “j” are pixel index. The filter kernel W_{ij} is a function of the guidance image I and independent of p. This filter is linear with respect to p.

The guided filtering kernel W_{ij} is given by:-

$$w_{ij} = \frac{1}{|w|^2} \sum_{k:(ij) \in w_k} \left(1 + \frac{(I_i - \mu_k)(I_j - \mu_k)}{\sigma_k^2 + \epsilon} \right) \dots \dots \dots (5)$$

In this eqn. I is the guidance image, p is the input image, w_{ij} is the filter kernel is the variance, K_i is the normalizing parameter, w_k is the window centered pixel at pixel k and μ_k is mean of I.

Zero Padding:

It is preferable to periodic replication in various applications because it circumvents wrap-around problems with little increase in computational cost. In this way wavelet analysis is different from Fourier analysis, in which periodic replication is necessary due to the periodic nature of the basis function. In Fourier analysis the term “zero padding” refers to extending the signal with a finite number of zeros. Periodic replication does retain certain attractiveness in wavelet analysis, however, due to its computational simplicity and its convenient analytical properties [13].

For signals that do not begin or end on the baseline, the appropriate methods of extension are mirroring or extrapolation, in order to prevent discontinuities at the boundaries. The relative pros and cons of extrapolation versus mirroring are less clear than those zero padding versus periodizing. Generally filters are used to filter discarded belongings or thing in a spatial domain or its surface area. In the area of image processing maximum time the images are pretentious by several of noises. The major objectives of filters are to improve the quality of an image by improving interoperability of the present information into images.

Frequency Domain

The frequency domain method is based on the convolution theorem. It splits an image from its spatial domain form of intensity into frequency domain [2] components and it is symbolized as the above equation 1 & equation 2.

Spatial Filters

When filtering functions are unswervingly performed on the pixels of an image are referred as Spatial Filtering. Spatial filtering consists basically affecting the filter mask from point to point in an image. At every point(x, y), the reaction of the filter at that point is designed using a predefined relationship.

3.4 Proposed Method

High pass filters: A high pass filter is mostly used for sharpening purpose. When an image is sharpened and contrast is superior between bordering areas with little variation in brightness or low eminence information.

$$High\ pass = f(x, y) - low\ pass \dots \dots \dots$$

High-boost Filtering: A high-boost filter is also acknowledged as a high-frequency prominence filter. A high-boost filter is used to conserve numerous of the low-frequency apparatus to abet in the elucidation of an image. In high-boost filtering input image h (m, n) is multiplied by an amplification factor A prior to subtracting the low-pass image. Accordingly, the high-boost filter expression is:

$$High\ Boost = A * f - low\ pass \dots \dots \dots (7)$$

Adding and subtracting 1 with gain factor, then

$$High\ Boost = (A - 1) * f(x, y) + f - low\ pass$$

So

$$High\ Boost(A - 1) * f + High\ pass \dots \dots \dots (8)$$

Steps Followed by enhancement are:

1. Input an image (x-ray, MRI).
2. Apply DWT (dual tree).

3. Decompose image into (LL, LH, HL, HH) sub bands.
4. Apply Kernel with zero padding in LL band using the given equation

$$w_{ij} = \frac{1}{|w|^2} \sum_{k:(ij) \in w_k} \left(+ \frac{(I_i - \mu_k)(I_j - \mu_k)}{\sigma_k^2 + \epsilon} \right)$$

5. Apply high pass filter into LL, LH, HH bands using the given formula.

$$\text{High pass} = f(x, y) - \text{low pass}$$

6. Then apply Gaussian filter to remove noise

$$h(m, n) = \left[\frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{m^2}{2\sigma^2}} \right] \times \left[\frac{1}{2\pi\sigma} e^{-\frac{n^2}{2\sigma^2}} \right]$$

7. In parallel apply HE into padded LL band.
8. Apply high boost filter after removed noise from LH, HL, HH sub bands.

$$\text{High Boost} = (A - 1) * f(x, y) + \text{High pass}$$

9. Compose all layers.
10. Apply inverse function of DWT (IDWT).
11. Measure MSE (original image ,

Enhanced image)

$$MSE = \frac{1}{mn} \sum_{i=0}^{m-1} \sum_{j=0}^{n-1} [I(i, j) - K(i, j)]^2$$

12. Measure PSNR (peak signal-to-noise ratio).

$$PSNR = 10 \log_{10} \frac{MAX_I^2}{MSE}$$

13. Measure MAE (mean absolute error)

$$MAE = \frac{1}{n} \sum_{t=1}^n |x_t - \hat{x}_t|$$

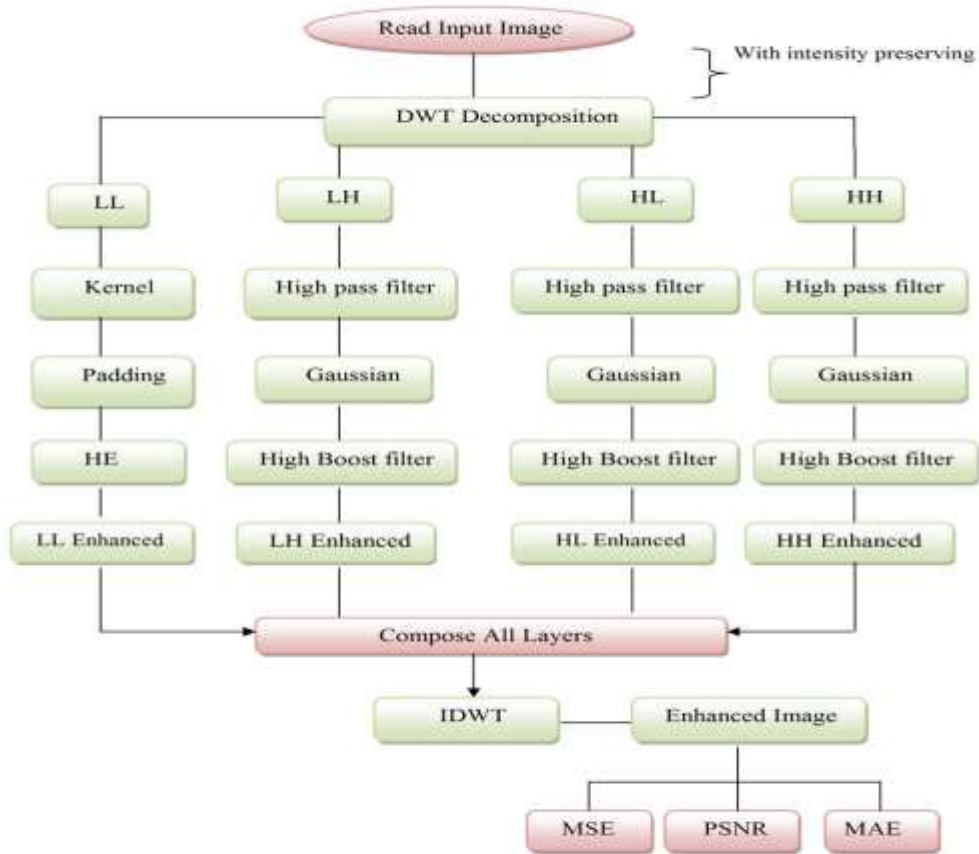


Figure 4: Block Diagram of proposed enhancement method

Figure 4 shows that the working diagrams of proposed system where low quality images are enhanced with it. Additionally Gaussian filter is embedded into this system, who removes the noise from the images. Basically Gaussian filter is linear smoothing filter with the weights selected according to the Gaussian functions. Primarily these kind filters are used to level

4. EXPERIMENTAL RESULTS & ANALYSIS

In this section we demonstrate the effectiveness of our proposed methodology DTCWT with HBF in comparison with some existing approach HE, DWT and High Boost Filter for contrast enhancement. The simulation is done on MATLAB2012a [15] & analysis of our method is performs using performance metrics such as MSE and PSNR.

For the experimental process they have tested 5 X-ray-MRI images, and in figure 5 show the comparison of different methods for chest x-ray image, similarly they have tested contrast enhancement foot-x-ray, hands-bone, head-x-ray and mummy-x-ray images.

MSE: Mean Square Error

The MSE is the cumulative squared error between the compressed and the original image

$$MSE = \frac{1}{mn} \sum_{i=0}^{m-1} \sum_{j=0}^{n-1} [I(i,j) - K(i,j)]^2$$

PSNR: Peak Signal-To-Noise Ratio

It is the ratio between the maximum probable power of a signal and the power of corrupting noise that influences the fidelity of its representation. For the reason that many signals have a extremely extensive dynamic range, PSNR is typically expressed in terms of the logarithmic decibel scale.

The PSNR (in dB) is defined as

$$PSNR = 10 \log_{10} \frac{MAX_I^2}{MSE}$$

MAE: Mean Absolute Error

MAE measures the average magnitude of the errors and is defined as follows:

$$MAE = \frac{1}{n} \sum_{t=1}^n |x_t - \hat{x}_t|$$

Where x_t and \hat{x}_t denote the samples of original image and enhanced image, respectively. M and N are number of pixels in row and column directions, respectively.

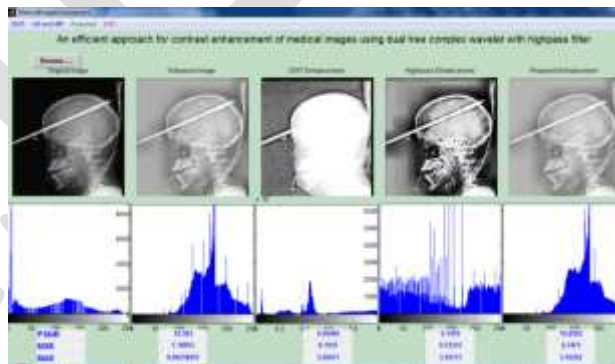


Figure 5: Shows the result produced by method HE, DWT, HBF and Proposed on mummy- x-ray

From the above figure we observe that the existing HE, DWT and HBF method does not execute well that part of the image which is much darker region but after analyzing our method with these method, we found that our method DTCWT with HBF produce much better results and enhance the contrast of the images.

Here, we are showing the performance of five medical images and analyze it on the basis of MSE (mean square error) and PSNR (peak signal noise ratio), MAE (mean absolute error)

After observing the table 1 found that the MSE value of our proposed method is much better than the HE, DWT and High Boost.

Table 1: Comparison of 5 medical images using various methods on MSE

MSE comparison				
Method/ Image	HE	DWT	High Boost	Proposed
chest-x-ray	6.6923	12.1548	6.13787	5.52765
mummy-x-ray	10.1678	7.02954	11.3795	12.1732
hands-bone	7.25542	11.4552	7.17098	5.90256
foot-x-ray	12.7051	7.71594	10.3744	10.4141
head-x-ray	10.8502	9.69466	9.19786	8.64066

In table 2 we also analyze that the result of PSNR value of five medical images comparing it with methods and obtain more PSNR than the HE, DWT and High boost which efficiently reduce and enhance the contrast or brightness of the image.

Table 2: Comparison of 5 medical images using various method on PSNR

PSNR comparison				
Method/ Image	HE	DWT	High boost	Proposed
chest-x-ray	15.1418	4.77495	16.6441	18.4632
mummy-x-ray	7.8757	7.02954	11.3795	12.1732
hands-bone	13.7383	5.80466	13.9416	17.3232
foot-x-ray	4.00569	12.6692	7.5262	7.45994
head-x-ray	6.7473	8.7035	9.61732	10.7029

In table 3 we also analyze that the result of MAE value of five medical images comparing it with methods and obtain less MAE than the HE, DWT and High boost which efficiently reduce and enhance the contrast or brightness of the image.

Table 3: Comparison of 5 medical images using various methods on MAE

MAE comparison				
Method/ Image	HE	DWT	High Boost	Proposed
chest-x-ray	6.6923	12.1548	6.13787	5.52765
mummy-x-ray	3.1678	7.02954	6.3795	2.1732
hands-bone	7.25542	6.4552	6.17098	5.90256
foot-x-ray	3.7051	4.71594	6.3744	2.4141
head-x-ray	7.8502	9.6946	4.1978	1.6406

5. CONCLUSION & FUTURE SCOPE

In medical application, to acquire improved quality of medical data various techniques has been implemented which enhance the contrast and preserve the brightness of image but they are not much efficient. Our proposed method DTCWT with high boost filter enhances the contrast of medical image it also reduces the noise and blur of the image than the existing methods. The MSE and PSNR results show that our method is more suitable for contrast enhancement.

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