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Image Enhancement Using Discrete Wavelet Transform based on Color Space Conversion Technique

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ABSTRACT

The image enhancement technique is most important technique to improve the quality of the image and visual appearance and to provide better representation for automated digital image processing. The major objective of the paper is to provide the novel algorithm to eliminate the Gaussian noise content and to improve the quality of the image. In this paper, the discrete wavelet transform (DWT) is proposed for smoothening and sharpening to improve the quality of the image. The main aim is to derive the wavelet transform coefficients in the new execution basis, the noise content can be removed from the image. The color image is considered for de-noising purpose to remove the noise content by applying DWT decomposition by converting the RGB (Red, Green and Blue) significance of each pixel of the original noise image to HSV (Hue, Saturation and Value) by giving comprehensive evaluation of proposed algorithm. The Gaussian noise is taken to the account and the proposed DWT algorithm is used to eliminate the Gaussian noise. The high frequency band is sharpened and low frequency sub-band is smoothened by applying non-linear filter. After converting RGB to HSV color space, the saturation band is enhanced by applying adaptive histogram equalization method. The V band is improved by applying illumination improvement and then all three HSV has to be converted back to RGB to reconstruct the original image with noise removal and high quality digital image.

1. Introduction

The image enhancement and filtering process has a major role for simple photographic to planetary image, medicine image, and satellite image. The image needs better quality in terms of its brightness and clarity to present the comfortable view for the human view. In order to get these requirements the researchers has proposed different types of techniques, to obtain the optimum quality of an image. In image processing the noise reducing process is plays a major role and the wavelet analysis is the powerful technique for decreasing noise from the original image. The wavelet method is introduced in the process of noise reduction and wavelet coefficients attained by wavelet decomposition. The obtained image is represented at different scales, after reducing the noise process from the image, the image again reconstructed by inverse wavelet transform technique. With help of two banks of filters the reconstructed is accomplished by perfect reconstruct condition. Depends upon the application the threshold selection of deionizing technique is varied. The images are distorted by various types of noise namely Gaussian noise, Salt and Pepper noise, Poisson noise, Speckle noise etc. These are the basic noise types of images. These noises come from the locality of where the images captured due to inaccuracy or imperfection, integral deficiency of image capturing devices like cameras. Contrary in atmosphere, misaligned of camera lenses, weakness of focal length, and scattering etc. these are type's sources of noise creation. These are important case study for denoising noise for the researchers, and this leads to selection of perfect noise model for image processing system. During image transfer or image acquisition the noise where placed in the images. This noise may occur because of the electronic or photometric sources. Bandwidth reduction of images present when the non-stationary camera placement, spreading of focal length etc. Due to the improper image formation the image blurring occurs.

In order to reduce the noise usually the linear technique where used, the linear technique is not performed in impulsive noise. Several non-linear technique is proposed by researchers to restore the images in spatial domain and wavelet domain or multi scale domain. Now days the wavelet transform based technique algorithm is used to achieve the extraordinary results on denoising noise. Before this technique Pixel based image denoising schemes used before.

In the period of last two decades numerous methods has been proposed by the researchers to enhance the denoising of the images. These methods are classified into two types one is spatial domain and transform domain denoising. In the spatial domain denoising technique, the process directly applied in the intensity levels. Local mean and variance method is used initially. In transform domain denoising method several transform is used such as Fourier transform, Short time Fourier transform, wavelet transform, cosine transform, curvelets transform, contourlets transform, etc. In the wavelet based image denoising method, threshold technique is the familiar one.

The image enhancement and color reproduction plays on major role for the development of visual quality of endoscopic image analysis. The modern endoscopic is allows the high definition images with large details. Capsule endoscopic is analyzing advanced tool for examining the three parts of small intestine - duodenum, jejunum, and ileum. Due to the high definition image of wired endoscopic the capsule endoscopic is too far behind and it has a limited power consumption. The different type of vascular abnormalities and mucosal early detection by high improved image quality. This is why the new techniques improved day by day. By the enhancement of particular mucosal or vascular characteristics so we can easily visualised the abnormal growth in better manner. Presently to enhance the certain characteristic of mucosal or vascular abnormalities, there are pre-processing and post processing systems used. The narrow band imaging (NBI) and Auto florescence imaging (AFI) can produce intestinal images with superior details. These techniques are comprises power consuming and hardware complexity of the endoscopic system. Virtual chromo endoscopy (CE) is another method it decays an image in to several wavelengths and reconstructed the image.

The human visual sensitivity of an image is impressively affected by the contrast and brightness of the images. The contrast is nothing but difference in the pixel intensity value of a certain pixel to its neighbor pixel. When the intensity difference is more, and then contrast of the image also more. The more contrast of image gives improved clarity of the image in terms of local information. The local information is very important to analyze whether the image is medical or astronomical applications. For examining or analyzing, diagnosing of the ailments we need the proper image of a cell. With the modern technology, the signal processing is used to get the quality of enhanced image. There are many techniques where involved over the years to get enhance image. Contrast technique is also one of the techniques used to enhance the image quality. There are two types of contrast stretching method one is global method another one is local method.

The global method of contrast stretching is regularly used method, it gives the satisfactorily good quality of images but lack in local information. The local method of contrast stretching is gives the enhancement of local details of the image, and lack in over all information of the pixel enhancement. One single technique cannot be the perfect method of enhancing image quality, the various methods are using enhance the image quality. But one type of technique may give best result for particular type of an image and may not for another type of image.

2. Literature Survey

Mr. Sachin Ruikar, Dr. D D Doye et al. has proposed Image Denoising Using Wavelet Transform. The image is frequently distracted by noise while transmission and acquisition, it very challenging work for the researchers who involved to removing noise from the original image. In this paper the threshold function is introduced to deionising algorithms, it is kind of new approach. It implements the wavelet transform for removing noise from the image. The proposed threshold function is improves the SNR efficiently, and it is compared with universal, Visu shrink, Sure Shrink and Bayes Shrink, normal shrink.

In the proposed system algorithm the block of the approximation coefficient. Then threshold function is calculated by utilizing the Bays threshold, normal threshold, Sure Shrink, Visu Shrink & universal threshold. When deionising each coefficient is threshold by comparing with a threshold; the value of the coefficient is kept when it is not smaller than the threshold otherwise set to be zero. Hence, the deionised image is obtained. The author compared the various deionising method in image processing community, but Lena image result only given in tabular column. By implementing the new proposed threshold function the results are improved extremely. With the help of wavelet shrinkage the optimal deionising is obtained where an image is corrupt with Gaussian noise [1].

Ajay Boyat, Brijendra Kumar Joshi, et al. has proposed Image Denoising using Wavelet Transform and Median Filtering. Even the variety of algorithm has been proposed still we has scope to improve the image deionising. The filtering or deionising noise from the original image is difficult because of noise is integral part of the image. The noise is occurred in an image when it is acquisition. The new method is introduced by the author to removes the noise part from the image, that is image deionising algorithm based on the combination of median filtering and wavelet transform. It improves the quality of the image and removes noise from the original image.

The wavelet decomposes the original image in order to obtain the level of satisfaction deionising image.

The proposed technique is examined in MATLAB result. The wavelet domain is witnessed that iterative noise and median filter based method gives the closely constant result for Peak Signal to Noise Ratio (PSNR) and Root Mean Square Error (RMSE) [2].

Aravind B. N, K. V. Suresh, et al. has proposed An Improved Image Denoising Using Wavelet Transform. The author consider the degradation due to the noise and particular additive Gaussian noise.

For the deionising noise the author proposed two step approach, initially stationary wavelet based deionising and the second spatial domain method. Both real and synthetic images are taken in to the simulation, the results illustrations shows improvement over existing methods. The images are used for the different requirements from simple image to medical, satellite, and research imaging. So, the image need to be clean and free from artifacts, to give the better information to the user. Due to the atmospheric conditions, lighting condition or camera sensors acquisition is continuously involved with some sort of degradation.

The proposed method have dual step to deionising the image, and reducing additive Gaussian noise. The author compared the obtained results with various types of wavelet based techniques, hence the proposed method gives improvements results over the existing methods. Peak signal to noise ratio (PSNR) and mean structural similarity index (MSSIM) are used to quantitative analysis, tabulated values indicate that , the our method performs better [3].

Mohammad Shamim Imtiaz and Khan A. Wahid et al. has proposed Image Enhancement and Space-variant Colour Reproduction Method for Endoscopic Images using Adaptive Sigmoid Function. The image enhancement has the major role in the development of visual quality for endoscopic images analysis. The proposed system improves the discover rate of differences existing in images. It is post-processing scheme, and no need of extra hardware in the image acquisition part. In the proposed method we have two stages namely, 1. Adaptive sigmoid function based image enhancement, 2. Space variant colour reproduction. Sigmoid function is continuous non-linear function, it is frequently used to neural network when the information is deficient. Usually R, G and B components where manipulated, in the proposed system the colour endoscopic image is converted into YCbCr colour space using below equation, and finally Y is used for image enhancing.

The image enhancement is achieved by using adaptive sigmoid function on the evenly disseminated grey pixels. The author focuses on the mucosal and vascular characteristics. The quality of obtained colour images is examined with various standard performance metrics. The obtained colour image is having high quality compared with existing methods [4].

Kambam Bijen Singh, Telajala Venkata Mahendra, et al. has proposed Image enhancement with the application of local and global enhancement methods for dark images. The image enhancement is very important to human comfortable visual; it comprises optimum clarity, brightness. For the enhancement of image there are many types of techniques available to give best quality of an image, one of the common techniques is global image contrast enhancement. This technique has issues on consideration of local details of an image.

The local details of an image are very important for scientific study of image such as body of the planetary, satellite pictures and medical images. For analysing a particular disorder the image local details are very significant. When utilizing either global contrast enhancement or local contrast enhancement, we faced trouble on brightness of the image. Hence, to avoid the discrepancy of individual enhancement methods the author proposed the method that using both the techniques. Initially the image is locally enhanced then again the output of the image is implemented in global enhancement method. Finally we get the image without losses of brightness; the author used MATLAB for stimulation for enhancement method. The simulation results are verified with the parameters of image quality [5].

3. Existing Methodology

Many algorithms and techniques were implemented for image preprocessing. The image filtering process was established using different transformation domains. The image filtering techniques was implemented in two different domains like spatial domain and frequency domain. The frequency domain is considered and implemented using various types of transformation techniques. The Fourier transform, Short time Fourier Transform (STFT), Wavelet Transform (WT), Discrete Cosine Transform (DCT), etc.

3.1 Disadvantages

The major disadvantage of FFT is that the edge information of the image is conveyed across frequency bands because of FFT and the method is not localized in space that time information is missing and the low pass filtering provides the result in slight loss of edge information.

The nonlinear filters are the spatial domain filters that often remove noses to a reasonable amount at the same time the cost of nose is still present in the image consequently that degrades the object information.

4. Types of Noises

4.1 Gaussian noise

Gaussian noise is frivolously allotted over the sign. Every pixel in noisy image is the sum of true pixel cost and a random Gaussian disbursed noise cost. This noise has a Probability Density Function [PDF] of the regular distribution. It is also called Gaussian distribution. It is miles a major a part of the study noise of an image sensor this is of the constant degree of noise in the darkish areas of the image.

The images are degraded by way of noise which is a few random errors. Noise might be picked together with the image at some stage intaking image, transmitting or for the duration of the processing. It could be based or independent of the image content. Kind of noise fashions are used to create different types of noise for the images. The probabilistic characteristics of the noise may be used to explain it. The regularly used idealized noise, which is also known as white noise, has the depth that does not decrease with growing frequency. A unique case of white noise is Gaussian noise. A random variable with Gaussian distribution has its possibility density given by using the Gaussian curve. Noise that's normally structured of the image sign happens while an image is transmitted thru a few channel.

The Gaussian Noise affected Image can be written as,

$$f(x, y) = g(x, y) + I(x, y)$$

where,

I(x,y) → Input Image
g(x,y) → Gaussian Noise
f(x,y) → Noisy Image

4.2 Salt and pepper noise

The salt-and-pepper noise are also known as shot noise, impulse noise or spike noise that is normally due to defective memory places, malfunctioning pixel elements in the digital camera sensors, or there can be timing errors inside the technique of digitization .within the salt and pepper noise there are handiest feasible values exists that is a and b and the probability of every is less than zero.2.

If the numbers more than this numbers the noise will swamp out image. For 8-bit image the typical value for 255 for salt-noise and pepper noise is zero. Sources for Salt and Pepper Noise occurrence:

- By memory cellular failure.
- With the aid of malfunctioning of camera's sensor cells.
- By means of synchronization errors in image digitizing or transmission.

5. Proposed System

The RGB noisy image is converted into HSV image to improve its histogram color space conversion. The histogram improvement is useful to enhance the contrast and brightness of the image. The denosing is implemented using discrete wavelet transform (DWT). The discrete wavelet transform (DWT) is proposed for smoothening and sharpening to improve the quality of the image. The main aim is to derive the wavelet transform coefficients in the new execution basis, the noise content can be removed from the image. The color image is considered for de-noising purpose to remove the noise content by applying DWT decomposition by converting the RGB (Red, Green and Blue) significance of each pixel of the original noise image to HSV (Hue, Saturation and Value) by giving comprehensive evaluation of proposed algorithm. The Gaussian noise is taken to the account and the proposed DWT algorithm is used to eliminate the Gaussian noise. The high frequency band is sharpened and low frequency sub-band is smoothened by applying nonlinear filter. After converting RGB to HSV color space, the saturation band is enhanced by applying adaptive histogram equalization method. The H band is not modified, because if the changes in the H component may provide the color conflict on HSV bands. The V band is improved by applying illumination improvement and then all three HSV has to be converted back to RGB to reconstruct the original image with noise removal and high quality digital image.

5.1 Discrete Wavelet Transform

We begin by defining the wavelet series expansion of function $f(x) \in L^2(\mathbf{R})$ relative to wavelet $\psi(x)$ and scaling function $\phi(x)$. We can write

$$f(x) = \sum_k c_{j_0}(k)\phi_{j_0,k}(x) + \sum_{j=j_0}^{\infty}\sum_k d_j(k)\psi_{j,k}(x)$$

where j_0 is an arbitrary starting scale and the $c_{j_0}(k)$'s are normally called the approximation or scaling coefficients, the $d_j(k)$'s are called the detail or wavelet coefficients. The expansion coefficients are calculated as

$$c_{j_0}(k) = \left\langle f(x), \tilde{\phi}_{j_0,k}(x) \right\rangle = \int f(x)\tilde{\phi}_{j_0,k}(x)dx \quad (5.1.2)$$

$$d_j(k) = \left\langle f(x), \tilde{\psi}_{j,k}(x) \right\rangle = \int f(x)\tilde{\psi}_{j,k}(x)dx \quad (5.1.3)$$

$$W_\phi(j_0,k) = \frac{1}{\sqrt{M}}\sum_{x=0}^{M-1} f(x)\tilde{\phi}_{j_0,k}(x) \quad (5.1.4)$$

$$W_\psi(j,k) = \frac{1}{\sqrt{M}}\sum_{x=0}^{M-1} f(x)\tilde{\psi}_{j,k}(x) \quad (5.1.5)$$

for $j \geq j_0$ and

$$f(x) = \frac{1}{\sqrt{M}}\sum_k W_\phi(j_0,k)\phi_{j_0,k}(x) + \frac{1}{\sqrt{M}}\sum_{j=j_0}^{\infty}\sum_k W_\psi(j,k)\psi_{j,k}(x)$$

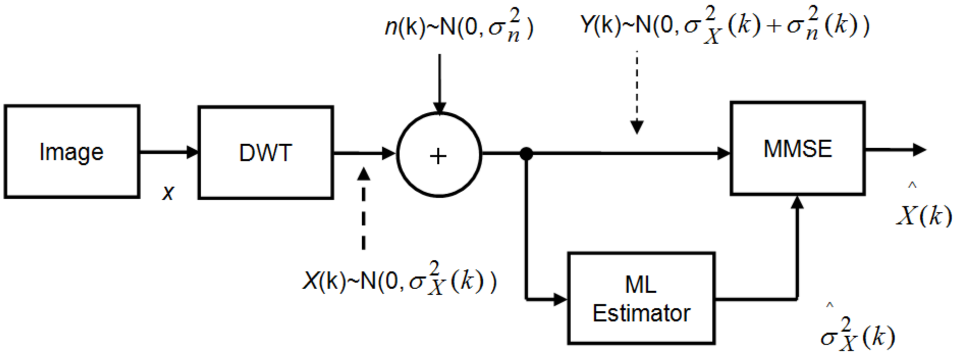
where $f(x)$, $\phi_{j_0,k}(x)$, and $\psi_{j,k}(x)$ are functions of discrete variable x = 0, 1, 2, ... , M – 1 [6].

5.2 The System model

Figure 1 shows that the proposed model. A noise contaminated image may be formulated as in the shown block-diagram. A "clean" image, x, is decomposed by DWT providing the wavelet coefficients X(k). These coefficients, which may be locally considered as i.i.d GGD random variables with variance $\sigma_X^2(k)$, are corrupted by additive Gaussian noise samples, n(k), to produce the observed wavelet coefficients of the noisy image, Y(k).

Let W and W^{-1} denote the two dimensional DWT and its inverse respectively. The relationship between image and transform coefficients is:

$$X = Wx \quad and \quad x = W^{-1}X \quad (5.2.1)$$



The "clean" coefficients, X, may be estimated from the observed coefficients, Y, if noise variance, σ_n^2 and image coefficient variance, $\sigma_X^2(k)$ are known.

$$x = W^{-1}X \qquad \wedge \qquad x = W^{-1}X$$

(5.2.2)

5.3 The mathematical estimation

It is known that the best estimate of a random variable x given by a MMSE (Minimum Mean Square Error) estimator is:

$$X = E[X] \qquad \wedge \qquad (5.2.3)$$

$$f_X \sim N(0, \sigma_X^2,$$

$$f_Y \sim N(0, \sigma_X^2 + \sigma_n^2) \qquad (5.2.4)$$

$$f_{Y|X} \sim N(x, \sigma_n^2)$$

$$f_{X|Y} = \frac{f_{Y|X}\, f_X}{f_Y} = \frac{N(x, \sigma_n^2)\, N(0, \sigma_X^2)}{N(0, \sigma_X^2 + \sigma_n^2)} \qquad (5.2.5)$$

If the Gaussian distributions are replaced by their explicit forms, equation (5.2.5) results in:

$$f_{X|Y} \sim N\left(\frac{\sigma_X^2}{\sigma_X^2 + \sigma_n^2} y, \frac{\sigma_X^2 \sigma_n^2}{\sigma_X^2 + \sigma_n^2}\right) \qquad (5.2.6)$$

The estimated "clean" wavelet coefficients result by considering equations (5.2.3) and (5.2.6):

$$X(k) = \frac{\sigma_X^2}{\sigma_X^2 + \sigma_n^2} Y(k) \qquad (5.2.7)$$

But in fact σ_X^2 is not known, so we employ a ML estimator in order to have an estimate for a local neighborhood, σ_X^2, where variance is assumed to be constant. The ML estimate is defined as:

$$X_{ML}(y) = \arg\max_{x}\ f_{Y|X}(y \mid x) \qquad (5.2.8)$$

In our case, this takes the following form:

$$X_{ML}(y) = \arg\max_{\hat{\sigma}_y^2} \prod_{j \in \mathrm{N}} f(y, \sigma_y^2) \qquad (5.2.9)$$

where N is the local neighborhood. The above technique can be written as equation,

$$\sigma_y^2 = \frac{1}{M}\sum_{k=1}^{M} Y^2(k) \qquad (5.2.10)$$

$$\hat{\sigma}_X^2 = \frac{1}{M}\sum_{k=1}^{M} Y^2(k) - \sigma_n^2 \qquad (5.2.11)$$

Finally, the "clean" coefficients are estimated combining (5.2.7) and (5.2.11):

$$\hat{X}(k) = \frac{\hat{\sigma}_X^2}{\hat{\sigma}_X^2 + \hat{\sigma}_n^2} Y(k) \qquad (5.2.12)$$

$$\sigma_n^2 = \left[\frac{median\,(|Y(k)|)}{0.6745}\right]^2 \qquad (5.2.13)$$

where Y(k)represent the coefficients of HH_1 sub-band [7].

We know that the low resolution image may be obtained by passing the high resolution image through a low pass filter in frequency domain, that absolutely implies that the LL sub-band is that the low resolution of the input image. The proposed improvement method is predicated on the interpolation of HF sub-band image obtained by DWT and input image. The sting detail is increased by exploitation intermediate stage exploitation DWT. DWT may be accustomed decompose the input image into totally different sub-bands, and so the HF sub-bands ar interpolated. HF sub-bands obtained by SWT of input ar incremented into interpolated HF sub-bands so as to correct the calculable co-efficient. In parallel input image is additionally interpolated singly and corrected HF sub-bands and interpolated input image ar combined through IDWT, to realize high resolution output. Here the most role of frequency transforms is to preserve the HF parts. One level DWT may be accustomed decompose the input image to totally different sub-bands. whereas interpolating the HF parts, we tend to used bi-cubic interpolation with enlargement issue of two. Down sampling in every of DWT sub-bands causes info loss in respective sub-bands. thus we tend to use DWT to reduce the error. It may be discovered that interpolated HF sub-bands and the DWT HF sub-bands have same size, and thus they will be another along. Basically the LL sub-band is that the illumination info of low resolution image. rather than exploitation LL sub-band, that contains less info than the initial image we tend to ar exploitation input image itself. Use of input image rather than low frequency sub-band will increase the standard of super resolved image in comparison with the traditional techniques. this can be because of the very fact that, the interpolation of HF parts in HF sub-bands and exploitation the corrections obtained by HF parts of DWT of the input image can preserve additional HF parts than the ordinary interpolation.

6. Results and discussion

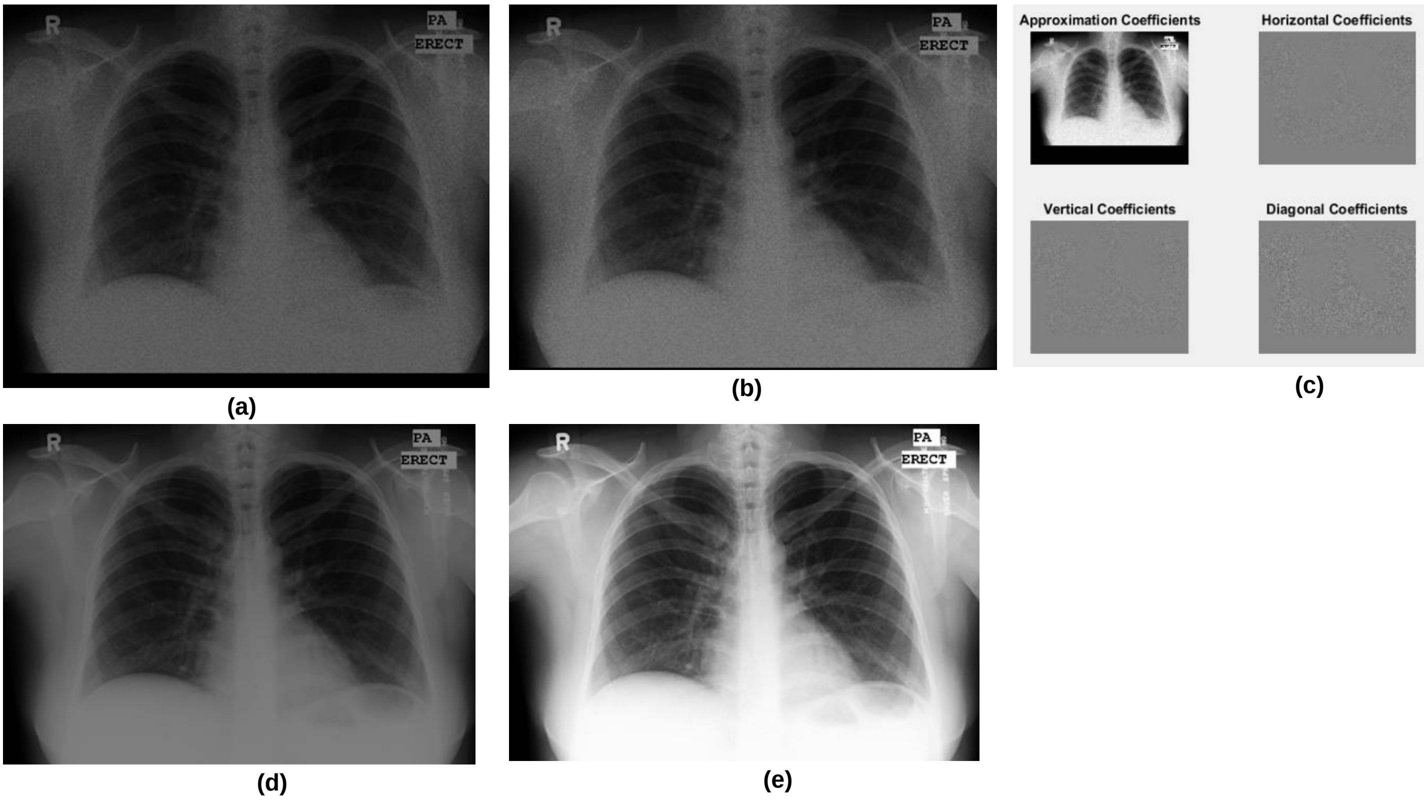
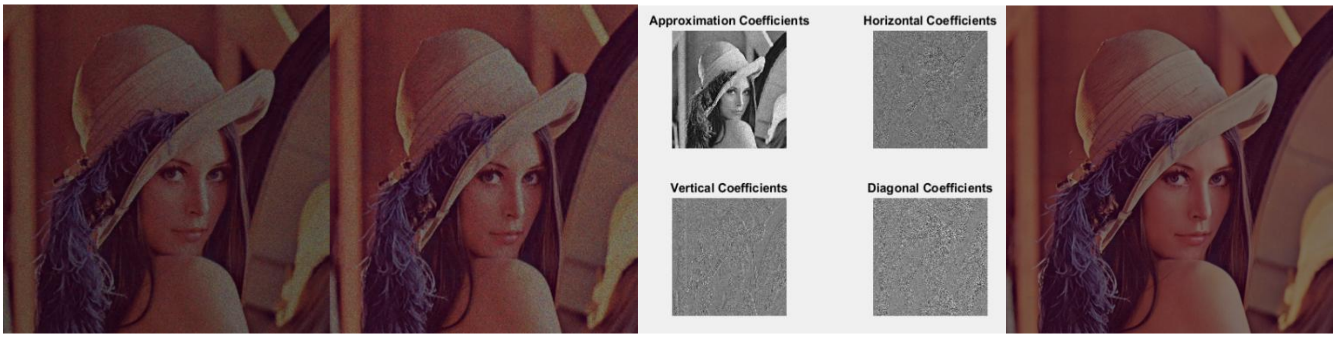


Figure 1) a). Input noisy image, b) HSV Image, c).DWT Coefficients, d).Filtered Image using DWT e). Enhanced Image

Figure 1 and 2 shows that the results of our proposed algorithm. Figure 1.a shows that the input noisy image with Gaussian noise distribution. The input noisy image is converted into HSV color space inorder to improve the quality of the image as shown in the figure 1.b. The DWT is applied on the HSV image to calculate the coefficients of the image as shown in the figure 1.c those are approximation coefficients, horizontal coefficients, vertical coefficients and diagonal coefficients. The DWT is used to remove the Gaussian noise as shown in the figure 1.d. The denoisy image is shown. The resolution of the image is improved and contrast of the image is enhanced as shown in the figure 1.e. The proposed algorithm is applicable for both medical and natural images. Figure 1 results show that the medical image preprocessing. Figure 2 results show that the natural image preprocessing.



(a) (b) (c) (d)

(e)

Figure 1) a). Input noisy image, b) HSV Image, c).DWT Coefficients, d).Filtered Image using DWT e). Enhanced Image

Table 1

Images	PSNR in dB	MSE
Medical Image	38.399	.0388
Leena Image	39.954	.0287

7. Conclusion

From the results obtained it is clear that the applying of the formula is useful in improving the image quality. And this application is more eminent in medical and natural image processing .This procedure is in getting the improved images to obtain even the small details once associated with images. The propsed DWT is useful to remove the Gaussian noise and improving the contrast and brightness of the image as shown in the results. The PSNR and MSE are calculated and tabulated.

8. Future Scope

The image segmentation is the useful technique to extract the region of interest. To segment the exact region of interest, the proper preprocessing is needed. The proposed preprocessing method is useful for further image segmentation process.

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