Medical Color Image Enhancement using Wavelet Transform and Contrast Stretching Technique

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Abstract- Low contrast and poor quality images are the main problems in the medical field. Wavelet transform based techniques are of greater interest because of their performance over Fourier and other spatial domain techniques. By using the wavelet transforms using Haar wavelet followed by the Laplacian operator to obtain the sharpened image gives a novel method for medical image enhancement. First, a medical image is decomposed with wavelet transform. Secondly, all high-frequency sub-images were decomposed with Haar transform. The contrast of the image is adjusted by linear contrast enhancement approaches. Filters are applied to identify the edges. Finally, the enhanced image was obtained by subtracting resulting image from the original image. Experiments showed that this method can not only enhance an image's details but can also preserve its edge features effectively.

Index Terms- Image Enhancement, Discrete Wavelet Transform, Color Conversion, Lifting DWT, Linear Contrast Stretching, Image Sharpening, RMSE, PSNR.

I. INTRODUCTION

A visual image is rich in information and many real world images are acquired with low contrast and poor quality, sometimes unsuitable for human eyes to read such medical and X-ray images. Image enhancement is a classical problem in image processing and computer vision. The image enhancement is widely used for image processing and as a preprocessing step in speech recognition, texture synthesis and many other applications. The main purpose of image enhancement is to bring out details that are hidden in an image or to increase contrast in a low contrast image[13]. Image enhancement is basically improving the interpretability or perception of information in images for human viewers and providing better input for other automated image processing techniques[16].

Medical image enhancement technologies have attracted much attention since advanced medical equipment's were put into use in the medical field. Enhanced medical images are desired by surgeons to assist diagnosis and interpretation because medical image qualities are often deteriorated by noise and other data acquisition devices, illumination conditions, etc. Also targets of medical image enhancement are mainly to solve problems of low contrast medical image. Image enhancement is the improvement of digital image quality without knowledge about the source of degradation[1]. Principle objective of Image enhancement is to process an image so that result is more suitable than original image for specific application[16].

The enhancement methods can broadly be divided into the following two categories[8][18]

- Spatial Domain Methods
- Frequency Domain Methods

In spatial domain techniques , we directly deal with the image pixels[16][8]. In this method pixel values are manipulated to get desired enhancement results. The value of pixel at coordinates (x,y) on enhanced image 'F' is the result of operations performed on the neighborhood of (x,y) on the input image 'f'. In frequency domain methods, the image is first converted into the frequency domain. In this process, the Fourier Transform of the image is computed first. All of the required enhancement operations are performed on the Fourier transform of the image. All required enhancement operations are performed so that modification is done in the contrast of an image, in brightness of an image etc. As a consequence the pixel value (intensities) of the output image will be modified according to the transformation function applied to the input values. Image enhancement simply means, transforming an image f in to an image g using T. (Where T is the transformation. The pixel values in images f and g are denoted by r and s, respectively [5]. The pixel values r and s are related by the expression,

$$s = T(r) \qquad \ldots\ldots (1)$$

Where T is a transformation which maps a pixel value r into a pixel value s. The results of above transformation are mapped into the grey scale range as we are dealing here only with grey scale digital images. Therefore, the results must be mapped back into the range [0,L-1], where L=2k, k being the number of bits in

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the image being considered. Therefore, for an 8-bit image the range of pixel values will be[0, 255].

In conventional Fourier transform, we use sinusoids for basis functions. It can only provide the frequency information. Temporal information is lost in this transformation process. In some applications, we need to know the frequency and temporal information at the same time. Unlike Fourier transform, Wavelet transform shows localization in both time and frequency and hence it has proved itself to be an efficient tool for a number of image processing applications [4]. Fourier transform based methods are less useful because, they cannot work on non-stationary signals but wavelets can do. Hence wavelet based noise removal has attracted much attention of the researchers for several years. Unlike conventional Fourier transform, wavelet transforms are based on small waves, called wavelets. It can be shown that we can both have frequency and temporal information by this kind of transform using wavelets. Wavelet analysis is similar to Fourier analysis in the sense that it breaks a signal down into its constituent parts for analysis. Whereas the Fourier transform breaks the signal into a series of sine waves of different frequencies, the wavelet transform breaks the signal into its "wavelets", scaled and shifted versions of the "mother wavelet"[6].

$$\psi_{a,b}(t) = \frac{1}{\sqrt{|a|}}\psi\left(\frac{t-b}{a}\right) \quad \ldots\ldots (2)$$

Where $a, b \in R$, $a \neq 0$

The parameter a is the scaling parameter or scale, and it measures the degree of compression. The parameter b is the translation parameter which determines the time location of the wavelet. If $|a| < 1$, then the wavelet in (2) is the compressed version (smaller support in time- domain) of the mother wavelet and corresponds mainly to higher frequencies. On the other hand, when $|a| > 1$, then $\psi_{a,b}(t)$has a larger time-width than $\psi(t)$ and corresponds to lower frequencies. Thus, wavelets have time-widths adapted to their frequencies. This is the main reason for the success wavelets in signal processing and time-frequency signal analysis.

Wavelet is irregular in shape and compactly supported. It is because of these properties of being irregular in shape and compactly supported that make wavelets an ideal tool for analyzing signals of a non-stationary nature [7].

There are many types of Wavelets like Haar Wavelet, Shannon Wavelet, Meyer wavelet, Daubechies Wavelet etc. for the analysis. Daubechies wavelets are very famous but haar wavelet are the simplest among wavelet families and suited well for binary images.

Wavelet Transform can be classified into continuous and discrete. Discrete Wavelet Transform (DWT) based image coding has better performance than traditional DCT based image coding, The DCT is similar to the discrete Fourier transform: it transforms a signal or image from the spatial domain to the frequency domain . DCT is real-valued and provides a better approximation of a signal with few coefficients. This approach reduces the size of the normal equations by discarding higher frequency DCT coefficients[17]. The enhanced image is reconstructed by using inverse DCT and it will be sharper with good contrast. The discrete wavelet transform (DWT) provides sufficient information both for analysis and synthesis of the original signal, with a significant reduction in the computation time[8].

DWT transforms, a discrete time signal to discrete wavelet representation[15]. By applying the 1-D discrete wavelet transform (DWT) along the rows of the image first, and then along the columns to produce 2D decomposition of image. DWT produce four sub bands low-low(LL), low-high(LH), high-low(HL) and high-high(HH).By using these four sub bands we can regenerate original image[10]. Theoretically, a filter bank shown in Fig. 1 should work on the image in order to generate different sub band frequency images. LL band contains more information whereas the remaining sub-bands constitutes the information of edges[3].

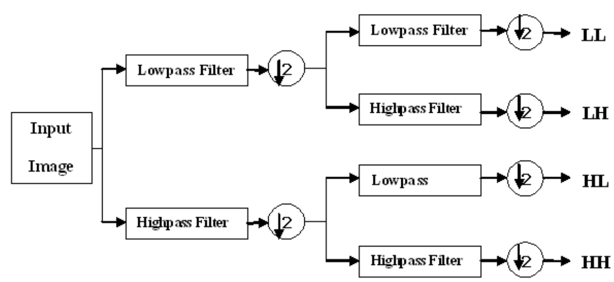

Figure 1: Discrete wavelet transform

Motivation:

Medical images are a special kind of images and are very important for diagnosis and correct interpretation. But images can be blur or may be of low contrast and poor quality. In such cases it will be difficult for surgeons to take the decisions. The principal objective of image enhancement is to modify attributes of an image to make it more suitable for a given task and a specific observer. Enhanced medical images are desired by surgeons to assist in diagnosis and interpretation. The result is more suitable than the original image for certain specific applications.

Contribution:

The Lifting DWT is used for image decomposition. We also used Linear Contrast Stretching to increase the brightness followed by Laplacian filter for the edge detection. Finally enhanced image is obtained by subtractions the sharpened image from original image. So we get the enhanced image which is visually appealing and with high PSNR value and low RMSE.

II . LITERATURE SURVEY

Dr. Muna F. Al-Samaraie et. all [1] have proposed 'Medical Colored Image Enhancemet using Wavelet Transform Followed by Image Sharpening' where a novel method for enhancing and sharpening medical color digital images is given. Low contrast and poor quality are main problems in the production of medical images. By using the wavelet transforms with Haar transform followed by using the Laplacian operator to obtain the sharpened image. First, a medical image was decomposed with wavelet transform. Secondly, all high-frequency sub-images were decomposed with Haar transform. Thirdly, noise in the frequency field was reduced by the soft-threshold method. Fourthly, high-frequency coefficients were enhanced by different weight values in different sub-images. Then, the enhanced image was obtained through the inverse wavelet transform and inverse Haar transform. Lastly, the filters are applied to sharpen the image; the resulting image is then subtracted from the original image. Experiments showed that this method can not only enhance an image's details but can also preserve its edge features effectively. The parameters measured is PSNR which is satisfactory.

Yashu Rajput et. all [2] proposed 'Advanced Image Enhancement Based on Wavelet & Histogram Equalization for Medical Images' where Image enhancement is used to produce high quality pictures like Medical images. As the quality of the image is very much depends on environmental effects like light, weather or equipment that we used to capture the picture, images may loose important information which is required to enhance the quality of an image. So we have many techniques to recover the lost data to improve the quality of the picture .Non linear enhancement technique is used to increase the contrast level of an image like wavelet transform and Histogram Equalization. In this experiment it is found that this method enhance the contrast level of an image.

Ganesh naga sai Prasad et. all[3] proposed 'Image enhancement using Wavelet transforms and SVD' where Resolution and contrast are the two important attributes of an image. In this paper developed a method to enhance the quality of the given image. The enhancement is done both with respect to resolution and contrast. The proposed technique uses DWT and SVD. To increase the resolution, the proposed method uses DWT and SWT. These transforms decompose the given image into four sub-bands, out of which one is of low frequency and the rest are of high frequency. The HF components are interpolated using conventional interpolation techniques. Then we use IDWT to combine the interpolated high frequency and low frequency components. To increase the contrast, we use SVD and DWT. The experimental results show that proposed technique gives good results over conventional methods.

Anamika Bhardwaj et. all [4] proposed 'A Novel approach of medical image enhancement based on Wavelet transform' where, by using the wavelet transform and Haar transform, a novel image enhancement approach is proposed. First, a medical image was decomposed with Haar transform. Then again high frequency subimages were decomposed secondly noise in the frequency field was reduced by the soft threshold method. Then high frequency coefficients are enhanced by different weight values in different sub images. Then the enhanced image was obtained through the inverse Haar transform. Lastly, the image's contrast is adjust by nonlinear contrast enhancement approaches. Experiments showed that this method can not only enhance an image's details but can also preserve its edge to increase human visibility.

III. PROPOSED MODEL

Input images are medical images. We have used both grayscale and color medical images. Our method works well for non medical images as well.

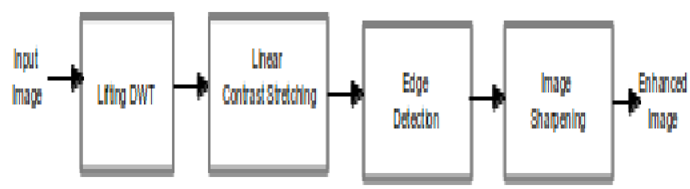

Figure 2 : The Image Enhancement Block for grayscale images

Figure 3 :The Image Enhancement Block for color images

Lifting DWT :

In Lifting Scheme, the signal is divided into odd and even signals. Later, a sequence of convolution and accumulation techniques is applied[12].

Steps involved in Lifting Scheme are[11]:
1. SPLIT
2. PREDICT
3. UPDATE

[1] SPLIT:
This step is performed in order to split the data into two smaller subsets i.e. even and odd
[2] PREDICT:
Here, we make use of the even samples that are multiplied by the prediction operator to predict the odd samples. Then the detail

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coefficient is obtained by taking the difference between the odd sample and the prediction value.

[3] UPDATE:

In this phase, the even samples are updated with detail to get smooth coefficient

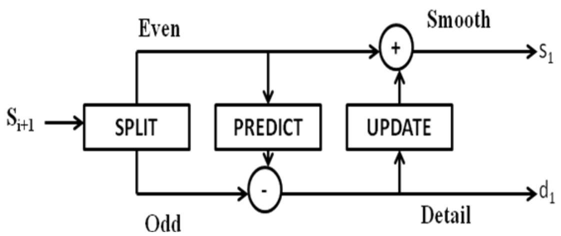

Figure 4: Wavelet Transform: Lifting- based implementation

RGB to HSV Conversion :

Color vision can be processed using RGB color space or HSV color space. RGB color space describes colors in terms of the amount of red, green, and blue present. HSV color space describes colors in terms of the Hue, Saturation, and Value. In situations where color description plays an integral role, the HSV color model is often preferred over the RGB model. RGB defines color in terms of a combination of primary colors R,G and B but the HSV model describes colors similarly to how the human eye tends to perceive color[1].

Equations used for color conversion is as follows :

$$H = \cos^{-1}\left\{ \frac{\frac{1}{2}[(R-g)+(R-b)]}{\sqrt{(R-g)2+(R-b)(G-b)}} \right\} \quad \text{….(3)}$$

$$S = 1 - \frac{3}{R+G+B}[min(R,G,B)] \quad \text{…. (4)}$$

$$V = \frac{1}{3}(r+g+b) \quad \text{…. (5)}$$

Linear Contrast Stretching :

The stretch used to rescale image data into brightness values can make a drastic difference in the way that the image appears. You can adjust the parameters of the stretch in order to maximize the information content of the display for the features in which you are most interested. This process is referred to as contrast stretching because it changes contrast in the image[1]. Contrast refers to the relative differences in the brightness of the data values. This technique modifies the linear contrast stretch that was related to the value transformation of the brightness part of the image. It can be measured by the lowest value of the brightness contrast (grey level = 0) to the highest value of the brightness contrast (grey level = 255) to full the grey scale level. A brightness value of between 0-255 would be spread out and could be calculated with the equation below :

$$g(x,y) = T[f(x,y)] \quad \text{…. (6)}$$

where,

g(x,y) = A brightness value of the area in the image at the exit

f(x,y) = The brightness value of the area at the entrance

T = The function for the linear transformation

Edge Detection :

Edges are significant local changes of intensity in an image. Edges typically occur on the boundary between two different regions in an image. Important features can be extracted from the edges of an image (e.g., corners, lines, curves). This method clearly defines the edges of the image. An edge point is a point at the location of a local intensity change. An edge detector is an algorithm that computes the edges in an image. Laplacian flter is used with eqn. [9]

$$\nabla^2 = \frac{4}{\alpha+1}\begin{bmatrix} \frac{\alpha}{4} & \frac{1-\alpha}{4} & \frac{\alpha}{4} \\ \frac{1-\alpha}{4} & -1 & \frac{1-\alpha}{4} \\ \frac{\alpha}{4} & \frac{1-\alpha}{4} & \frac{\alpha}{4} \end{bmatrix} \quad \text{…. (7)}$$

We have used the value for α is 0.8

Image sharpening :

The new approach enhancement model in this research begins with brightness enhancement. The algorithm of this technique was processed according to the sharpening model, which on the first stage, the color information of the digital image are transformed into grayscale image. Then, linear contrast stretch approaches to enhance the brightness of the image. The image is then edge detected by finding the second derivative of the Laplacian operator. Finally, increase the sharpness of the image by subtracting the result with the original image.

This step subtracts the edge detection output from original image and hence gives the enhanced image

.

$$f_{enh}(x,y) = f(x,y) - \nabla^2 T[f(x,y)] \quad \text{… (8)}$$

IV. ALGORITHM

Problem definition : Medical images are a special kind of images and are very important for diagnosis and correct interpretation. But images can be blur or may be of low contrast and poor quality or sometimes are distorted by noise during acquiring and transmissions. In such cases it will be difficult for surgeons to take the decisions. The principal objective of image enhancement is to modify attributes of an image to make it more suitable for a given task and a specific observer. Enhanced medical images are desired by surgeons to assist in diagnosis and interpretation. The result is more suitable than the original image for certain specific applications.

Objective:

- To increase PSNR
- To decrease MSE, RMSE

Input: Medical image

Output: Enhanced mage

Step 1: Read the input image

Step 2 : Check the dimensions if it is 2 then go to Step 5 else go to step 3

Step 3 : Apply RGB to HSV conversion

Step 4 : Retain H and extract S and V

Step 5 : Apply Lifting DWT. Get LL,LH,HL,HH band

Step 6: Extract only LL band and resize into original image size

Step 7 : Apply Linear Contrast Stretching using equation

Step 8: Perform Edge Detection using Laplacian filter

Step 9: Image sharpening by subtracting the output from step 8 from original image

Step 10 : Perform HSV to RGB conversion for color image

Step 11 : Enhanced image

Step 12 : Measure RMSE and PSNR

V. PERFORMANCE ANALYSIS & RESULT

For the set of input images performance of Lifting DWT with haar wavelet method followed by image sharpening is measured. Here for the purpose of performance measurement image with 256 x 256 resolution is used.

Subjective and objective evaluations are the types of evaluations which are helpful to examine the quality of the image. The image is observed by a human who has special knowledge of human visual system, in subjective evaluation. But this examining method of an image quality doesn't give efficient results because HVS, human vision system is complicated system.

So we choose subjective evaluation to measure the quality of an image. Various parameters are used to measure the image quality in objective evaluation of the image. Mean square error (MSE), Peak signal to noise ratio (PSNR), Root mean square error (RMSE) are the some of the metrics used here.

5.1. Performance parameters definition:

5.1.1 Mean square error (MSE)

Mean square error (MSE) is the quality measuring parameter which is used over a great extent, and is the simplest one among all other metrics. It is found by taking the average of the squared differences of the intensities of the original and estimated image [14][5].

For an image of size M x N the mean square error (MSE) is defined as :

$$MSE = \frac{1}{MN}\sum_{x=0}^{M-1}\sum_{y=0}^{N-1}(f(x,y) - f_{enh}(x,y))^2 \quad \text{…. (9)}$$

5.1.2 Root mean square error (RMSE)

Root mean square error (RMSE) is the other quality examining metric of the image. It is obtained by taking square root over mean square error (MSE).

$$RMSE = \sqrt{\frac{1}{MN}\sum_{x=0}^{M-1}\sum_{y=0}^{N-1}(f(x,y) - f_{enh}(x,y))^2} \quad \text{…. (10)}$$

5.1.3 *Peak signal to noise ratio (PSNR)*

Peak signal to noise ratio (PSNR) is widely used quality metric. It is measured in logarithmic scale in decibels (dB). By calculating the ratio of maximum signal power to the maximum noise power we can find the PSNR value of the corresponding image. If PSNR value of the image increases, the quality of the image also increases gradually[15].

Here L reflects the the maximum possible pixel value of the image .If the K channel is encoded with a depth of 8-bit, then L= 2^8 - 1 = 255. PSNR is usually expressed in terms of the decibels scale .If a signal to noise ratio is high then the mean square error will be minimum[10].

Peak signal to noise ratio (PSNR) is defined as,

$$PSNR = 10\log_{10}\left(\frac{255^2}{MSE}\right) \quad \text{…. (11)}$$

VI. RESULT

The below figures shows the results of the existing DWT method and proposed Lifting DWT method. Grayscale medical image IM0006 and color medical image IM_0016 are used, and the comparison of the original image, DWT image and proposed method image enhancement is displayed.

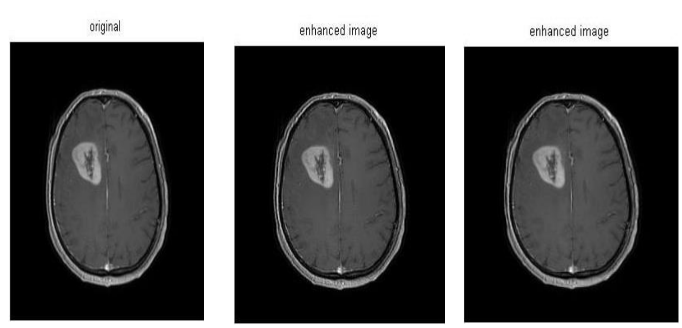

Figure 5 : Original grayscale Image, DWT Enhanced image ,Lifting DWT Enhanced Imag

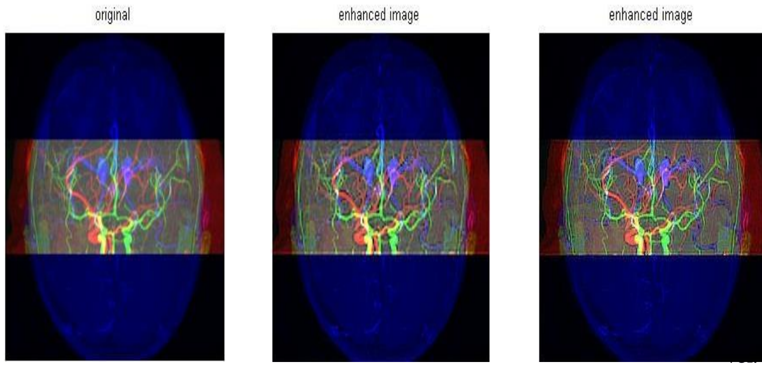

Figure 6 : Original Color Image, DWT Enhanced image ,Lifting DWT Enhanced Image.

From Table I, we observed that the PSNR value of the proposed Lifting DWT method is greater than the existing DWT method, and RMSE value is lesser than the existing method for different medical image input.

Table I: Comparison of RMSE and PSNR values for DWT method and proposed Lifting DWT method.

Image	Existing Method		Proposed Method	
	RMSE	PSNR(dB)	RMSE	PSNR(dB)
IM_0006	3.8321	36.4621	2.5385	40.0392
IM_0016	5.3203	33.6631	4.4323	35.2208
IM_0004(1)	5.2129	33.7893	3.3934	37.5181
IM_0001-005.dcm	6.0677	32.4703	3.5967	37.0128
r5b.jpg	7.0077	31.2202	5.7832	32.8943

VII. CONCLUSION

An important problem of medical image enhancement based on wavelet transform is how to extract high-frequency information. Haar transform is used to decompose the high-frequency sub-images of wavelets in this algorithm. This helps us to extract high-frequency information effectively. Different enhancement weight coefficients in different sub-images and Edge sharpening are used in the process of medical image enhancement. They can also help us to enhance a medical image effectively. Results of experiments show that the algorithm not only can enhance an image's contrast, but also can preserve the original image's edge property effectively. We use one level CDF 5/3 lifting DWT to decompose an image. The sharpening method procedure was experimented with additional steps. We first transform the image from color image into grayscale, then begin edge detecting with Laplacian technique. The edge detected image is then subtracted n the original image. The output image after enhancement of high quality.

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