International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 2 Issue 6, June - 2013

Image Denoising Technique Using Wavelet Decomposition And Reconstruction Based On Matlab

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Abstract
Wavelet transform plays an important role in the image processing technique. In this correspondence, we mainly introduced an image denoising algorithm based on interpolation of the high frequency subband images obtained by discrete wavelet transform (DWT) and the input image. The images are enhanced by introducing an intermediate stage by using stationary wavelet transform (SWT). DWT is applied in order to decompose an input image into different subbands. Then the high frequency subbands as well as the input image are interpolated. The estimated high frequency subbands are being modified by using high frequency subband obtained by SWT. Then all these subbands are combined to generate a new denoised image by using inverse DWT (IDWT). The quantitative and visual results show the superiority of the proposed technique over the conventional and state of art image enhancement techniques. The PSNR using different image enhancement technique are calculated with the help of MATLAB R2010a and it is found that, the PSNR of the proposed technique is superior to the previous technique used.

1. Introduction

In the last fifteen to twenty years, wavelet analysis developed in branch of mathematics and is used in much signal processing widely, especially image processing analysis. Now a day's wavelet is playing the most influential role in the field of communication system engineering. At the same time, it is the most simple and dynamic techniques to obtain the reconstructed signal. In this modern era of computing, MATLAB plays more and more widely in mathematics calculation outside of science and engineering application fields, especially in communications. Communication system simulation of MATLAB can be used in the constructing inconvenience, but it is easily operated. At the same time, many special toolbox and modules are provided. Denoising images are becoming an important aspect of an image. Images are mainly processed in order to get better PSNR values. One of the commonly used techniques for denoising images is interpolation [11]. Interpolation has been widely used in many image processing applications such as facial reconstruction, multiple description coding, and super resolution, in the same way here it is also used. There are three well known interpolation techniques, namely nearest neighbour interpolation, bilinear interpolation, and bicubic interpolation. Image denoising in the wavelet domain is a relatively new research topic and recently many new algorithms have been proposed. Discrete wavelet transform (DWT) is one of the recent wavelet transforms used in image processing. DWT decomposes an image into different subband images [5][11], namely low-low (LL), low-high (LH), high-low (HL), and high-high (HH). Another recent wavelet transform which has been used in several image processing applications is stationary wavelet transform (SWT). In short, SWT is similar to DWT but it does not use down-sampling, hence the subbands will have the same size as the input image. But input image and the subband obtained by using DWT are interpolated [11] with factor $\alpha/2$ [7], [8]. In this work, we mainly introduce an image enhancement technique which generates sharper denoised image. The proposed technique has been compared with conventional and state of art image denoising techniques. According to the quantitative and qualitative experimental results, the proposed technique over performs the aforementioned conventional and state of art techniques for image denoising technique. For this PSNR had been calculated and studied using different interpolation technique for standard benchmark images and results are concluded.

The proposed technique [9] uses DWT to decompose a low resolution image into different subbands [5]. The interpolated high frequency subbands and the SWT high frequency subbands have the same size which means they can be added with each other. The new corrected high frequency subbands can be interpolated further for higher enlargement. Also it is known that in the wavelet domain, the low resolution image is obtained by lowpass filtering of the high resolution image. Then the three high frequency subband images have been interpolated using proposed methodology [9]. The high frequency subbands obtained by SWT of

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the input image are being incremented into the interpolated high frequency subbands in order to correct the estimated coefficients. In parallel, the input image is also interpolated separately. Finally, corrected interpolated high frequency subbands and interpolated input image are combined and reconstructed by using inverse DWT (IDWT) to get a denoised output image.

2. System Model: Wavelet decomposition and reconstruction

Filters are one of the most widely used signal processing functions. Wavelets can be realized by iteration of filters with rescaling. The resolution of the signal, which is a measure of the amount of detail information in the signal, is determined by the filtering operations, and the scale is determined by up sampling and down sampling (sub sampling) operations. These are determined in two stages, first one is the decomposition [3] and the second one is the reconstruction of the DWT signal [9]. The DWT is computed by successive low pass and high pass filtering of the discrete time-domain signal [10]. This is Mallat algorithm or Mallat-tree decomposition [1]. Its significance is in the manner it connects the continuous-time multiresolution to discrete-time filters. This is shown in figure 2.1.

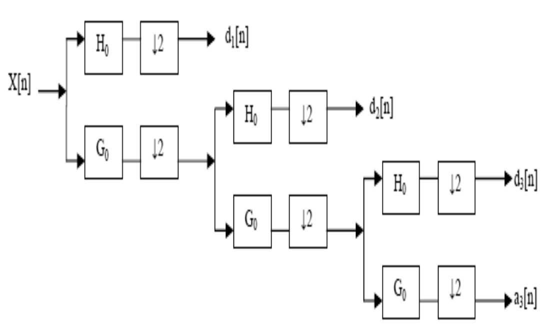

Fig. 2.1 Wavelet Decomposition Tree

In the above figure 2.1, the signal is denoted by the sequence x[n], where n is an integer. The low pass filter is denoted by G_0 while the high pass filter is denoted by H_0. At each level, the high pass filter produces detail information d[n], while the low pass filter associated with scaling function produces coarse approximations, a[n]. At each decomposition level, the half band filters produce signals spanning only half the frequency band. This doubles the frequency resolution as the uncertainty in frequency is reduced by half. The filtering and decimation process is continued until the desired level is reached. The maximum number of levels depends on the length of the signal.

Now, the DWT of the original signal is then obtained by collecting all the coefficients, a[n] and d[n], starting from the last level of decomposition. This is shown in figure 2.2.

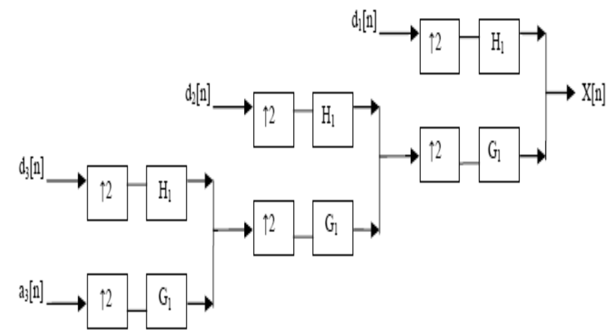

Fig. 2.2 Wavelet Reconstruction Tree

Above figure 2.2 shows the reconstruction of the original signal from the wavelet coefficients. Basically, the reconstruction is the reverse process of decomposition. The approximation and detail coefficients at every level are up sampled by two, passed through the low pass and high pass synthesis filters and it is then added. This process is continued through the same number of levels as in the decomposition process to obtain the original signal.

There are significant numbers of method for improving the image to get the good quality image. These methods include nearest neighbour interpolation (NNI), bilinear interpolation (BLI), bicubic interpolation (BCI) and wavelet zero padding (WZP). This work is done by using two level decomposition. The proposed technique algorithm [9] is shown in figure 2.3.

3. PSNR Estimation Scheme

Image denoising or improving the visual quality of a digital image can be subjective. Saying that one method provides a better quality image could vary from person to person. For this reason, it is necessary to establish quantitative or empirical measures to compare the effects of image enhancement algorithms on image quality.

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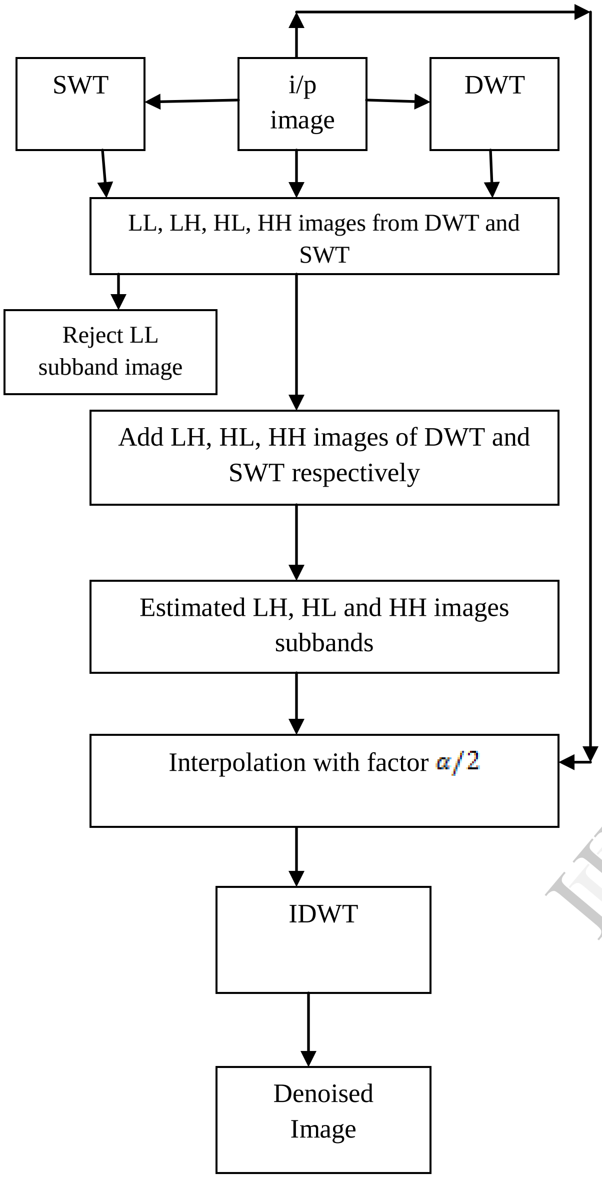

Fig. 2.3 Algorithm to obtain highly denoised image for the proposed technique

There are various parameters that are required to be study for the image quality. These can be studied by using signal to noise ratio (SNR), mean squared error (MSE) and peak signal to noise ratio (PSNR). The signal S(t) may or may not have a stochastic description, the noise N(t) always does. When the signal is deterministic, its power P_s is defined by equation 1 as,

$$P_s=\int_0^T S^2(t)dt \;\ldots\ldots(1)$$

where, T is the duration of an observation interval.
Let P_N be the noise power, then SNR is given by equation 2.

$$SNR=\frac{Ps}{PN} \;\ldots\ldots(2)$$

In decibel unit, SNR in expressed in equation 3,

$$SNR_{dB}=10\log_{10}\frac{Ps}{PN} \;\ldots\ldots(3)$$

PSNR is most easily defined by the mean squared error (MSE). Given a noise free m×n monochrome image I(i,j) and its noisy approximation K(i,j), MSE is defined as The mean squared error (MSE) between two images I(i,j) and K(i,j) is given by the equation 4.

$$MSE=\frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[\,I(i,j)-K(i,j)]^2 \;\ldots(4)$$

Thus, MSE is the square of the difference between the two images, where m and n are the number of pixels of the two images respectively.
PSNR avoids many problem of measuring image quality by scaling the MSE according to the image range. It is defined by the equation 5

$$PSNR_{dB} = -10\log_{10}\frac{MSE}{S^2}$$

$$= 10\log_{10}\frac{S^2}{MSE}$$

$$=20\log_{10}S^2-10\log_{10}MSE \;\ldots\ldots(5)$$

where, S is the maximum pixel value. PSNR is measured in decibels (dB). The PSNR measure is also not ideal, but is in common use. Its main failing is that the signal strength is estimated as S^2, rather than the actual signal strength for the image.
In the absence of noise, the two images I(i,j) and K(i,j) are identical, and thus the MSE is zero. In this case the PSNR is undefined

4. Result

In order to show the effectiveness of the proposed method over the conventional and state of art image

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denoising techniques. Some test images with different feature are used for comparison.

Figure 4.1 shows that super resolved image of dolphin fountain using proposed technique in (e) are much better than the input image in (a), super resolved image by using bilinear interpolation in (b), super resolved image by using bicubic interpolation in (c) and WZP in (d).

(a) Input Image

(b) Bilinear Interpolation Image (BLI)

(c) Bicubic Interpolation Image (BCI)

(d) Wavelet Zero Padding Image (WZP)

(e) Proposed technique

Fig. 4.1 View of image using different image denoising technique

The table 4.1 shows the obtained PSNR value using different interpolation technique for the different bench mark images. These are the standard images that had been studied on MATLAB R2010a to get the PSNR values.

Images	METHOD ADOPTED FOR IMAGE DENOISING			
	BLI	BCI	WZP	Proposed Method
Lena	29.28	31.30	36.48	36.87
Barbara	28.07	30.11	35.40	35.71
Baboon	27.71	29.68	34.86	35.04
Dolphin Fountain	27.08	29.11	34.48	34.73
Banana Grapes	29.04	31.01	36.51	36.70
Mangoes	28.44	30.49	35.94	36.19
Swan	29.57	31.55	37.19	37.36

5. Conclusion

As the image denoising technology is advancing and as we are getting better PSNR values, we can conclude that an image denoising technique based on the interpolation of the high frequency subbands obtained by DWT, correcting the high frequency subband estimation by using SWT high frequency subbands, and the input image. The proposed technique uses DWT to decompose an image into different subbands, and then the high frequency subband images have been interpolated. The interpolated high frequency subband coefficients have been corrected by using the high frequency subbands achieved by SWT of the input image. An original image is interpolated with half of the interpolation factor used for interpolation the high frequency subbands. Afterwards all these images have been combined using IDWT and we regenerate a super resolved imaged.

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