Image Resolution Enhancement using Discrete, Stationary and Dual Tree Wavelet Transform

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***Abstract*—Image resolution enhancement technique based on interpolation of the high frequency subband images obtained from discrete, stationary and Dual tree Complex wavelet transform(DT-CWT).In this study, a comparison of two image resolution enhancement techniques in wavelet domain is done. Each method is analyzed quantitatively and visually. On the basis of analysis, the most efficient method is proposed. The algorithms uses low resolution image as the input image and then wavelet transform is applied to decompose the input image into different high and low frequency subbands. Then these subband images along with the input image are interpolated. Finally all these images are combined to generate a new resolution enhanced image by using inverse process.**

Keywords*— Discrete Wavelet Transform, Stationary Wavelet Transform, Dual Tree Complex Wavelet Transform Interpolation.

I. INTRODUCTION

Resolution is an important property of an image. Image resolution enhancement is the process of manipulating an image so that resultant image is of good quality image. So to increase the resolution of image there are some few techniques are available. But to increase the resolution of image the best technique is bicubic interpolation with the help of DWT and SWT decomposition [1]. The interpolation technique has been used in many image processing applications such as super resolution [2-3]. Multiple description coding [4] and facial reconstruction [5].Image resolution enhancement in wavelet domain is relatively a new research topic. Discrete wavelet transform (DWT) [6] is one of the recent wavelet transforms used in image processing. DWT decomposes an input image into different subband images, like low-low (LL), low-high (LH), high-low (HL), and high-high (HH). Another recent wavelet transform which has been used in different image processing applications is stationary wavelet transform (SWT) [7]. In short, SWT is similar to DWT but it does not use down-sampling due to this the subbands will have the same size as the input image.

In this work, two different image resolution enhancement techniques are proposed which gives sharper high resolution image. In first technique DT-CWT is applied on input image to decompose input image into different sub-bands. The high frequency sub bands obtained from DT-CWT decomposition are interpolated using bicubic interpolation and these interpolated images are combined by using IDT-CWT to get high resolution image. In second technique DWT and SWT is applied on input image to get high frequency subband image. These high frequency sub bands are interpolated using bicubic interpolation technique and interpolated images are combined by using the inverse DWT to achieve the high resolution image. Both these proposed techniques are compared to get efficient technique

II PROPOSED METHODS

A) DT-CWT technique

To increase the resolution of image, preserving the edges is important. Because image resolution enhancement using interpolation causes loss on its high frequency components, this is caused due to interpolation which smoothens the image hence it is essential to preserve the edges.

In this technique, DT-CWT has been employed in order to preserve edges (i.e) high-frequency components of the image. The DT-CWT has good directional selectivity as compaired to discrete wavelet transform (DWT).The DT-CWT is approximately shift invariant, unlike the critically sampled DWT. The redundancy and shift invariance of the DT-CWT means that DT-CWT coefficients are inherently interpolable[8].In this method, DT-CWT is used to decompose an input image into different low and high frequency subband images. Six complex-valued high-frequency subband images contain the high-frequency components of the input image. An interpolation is applied to these high-frequency subband images. In the wavelet domain, the low-resolution image is obtained by lowpass filtering of the high-resolution image [9]. i.e, low-frequency subband images are the low resolution of the original image. Therefore, instead of using low-frequency subband images, which contain less information, we are using the input image for the interpolation. Hence, using the input image instead of the low-frequency subband images increases the quality of the high resolution image.The input image is interpolated with the half of the interpolation factor α used to interpolate the high-frequency subbands, as illustrated in Fig. 1. By interpolating the input image by $\alpha/2$ and high-frequency subband images by α and then following inverse process by using IDT-CWT, gives output image which contain sharper edges than the output image obtained by interpolation of the input image directly. In short, the proposed technique interpolates both the input image and the high-frequency subband images obtained through the DT-CWT process. The final high-resolution output image is obtained by using the IDT-CWT of the interpolated subband images and the input image.

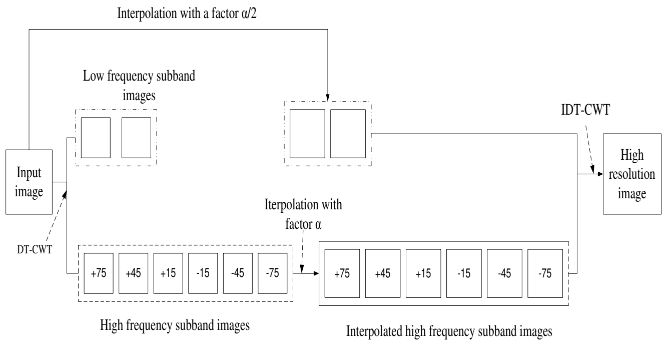

Fig.1. Block diagram of DT-CWT

The real 2-D dual-tree DWT of an image x is implemented using two critically-sampled 2-D DWTs in parallel. Then for each pair of sub-bands sum and difference is calculated. The complex 2-D DT-DWT also gives wavelets in six distinct directions. The complex 2-D dual-tree is implemented as four critically-sampled separable 2-D DWTs operating in parallel as shown in figure(2).This 2-D structure uses four trees for analysis and synthesis. The pair of conjugate filters applied to two dimensional images (x, y) can be expressed as:

$$(h_x + jg_x)(h_y + jg_y) = (h_x h_y - g_x g_y) + j(h_x h_y + g_x g_y)$$

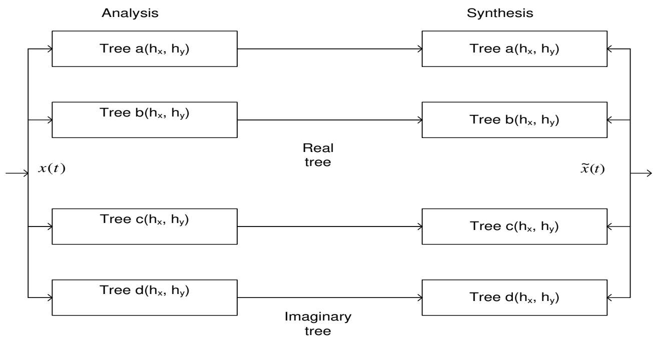

Fig. 2: Filter bank structure for 2-D DT-DWT

III. ALGORITHM

1. Input Low Resolution image.
2. Apply DT-CWT on input image.
3. Apply Bicubic interpolation with factor 4 and 2 to high frequency subband images of DT-CWT and input image respectively.
4. Add interpolated high frequency subbands of SWT and DWT technique to get the estimated sub-bands.
5. Apply IDWT to get high resolution image.

B) DWT SWT technique

This proposed technique uses low resolution image (m×n) then one level DWT is applied to decompose an input image into four different sub bands like LL, LH, HL, and HH. In this technique DWT is used to preserve the high frequency component of image. The Low-High (LH), High-Low (HL), High- High (HH) subband contains high frequency component of input image. Due to down sampling in DWT there is loss of information in subbands hence to minimize this loss SWT is used. The SWT technique decomposes the input image using haar wavelet into four different sub bands i.e. LL, LH, HL, HH. The high frequency output i.e. LH, HL and HH of DWT technique is interpolated by using the bicubic interpolation technique with enlargement factor of 4. LH, HL and HH of SWT technique is interpolated by using the bicubic interpolation technique with enlargement factor of 2. Now three high frequency components i.e LH, HH, HL of both DWT and SWT technique have the same size hence they are added together to get estimated high frequency sub-bands. These estimated high frequency sub-bands are again interpolated by factor α/4. Finally output of this bicubic interpolation and the original image which is interpolated by factor α/2 are combined by using inverse DWT (IDWT) to get the high resolution image. Figure3 shows the block diagram of proposed image resolution enhancement technique. Final high resolution image contains sharper edges than interpolation of input image directly.

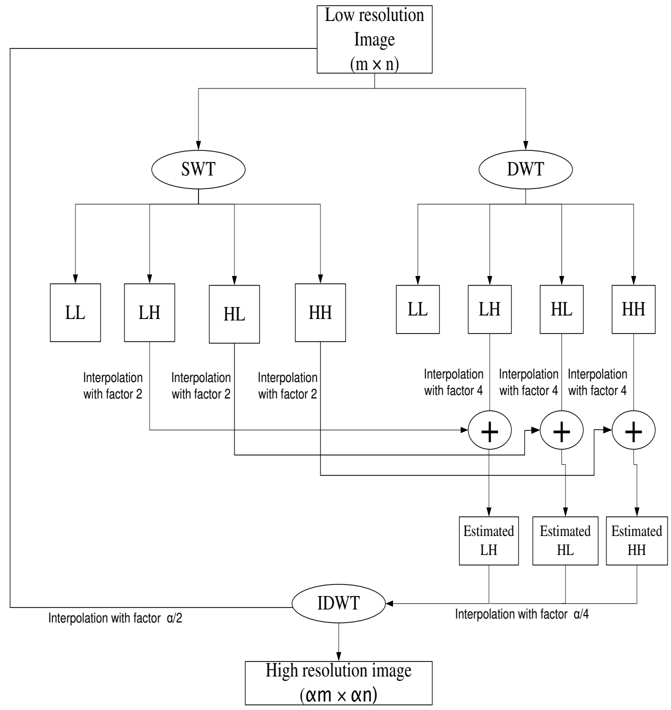

Fig3.Block diagram of DWT-SWT

The decomposition of image after applying one level DWT and SWT are shown in figure 4Low-Low (L.L) Low-High (LH.), High-Low(HL.), High-High (HH.) Frequency component.

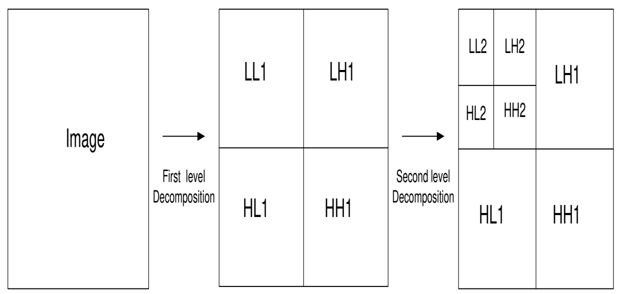

Fig.4. Structure of Wavelet decomposition

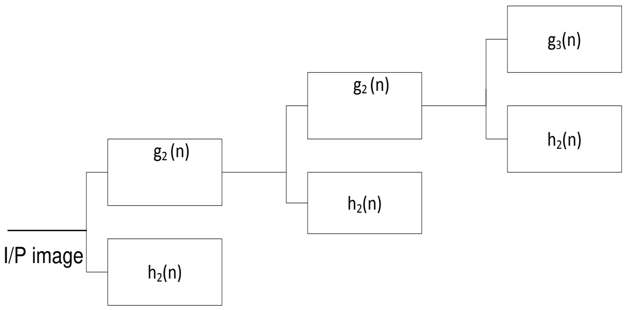

Fig.5. Structure of SWT decomposition

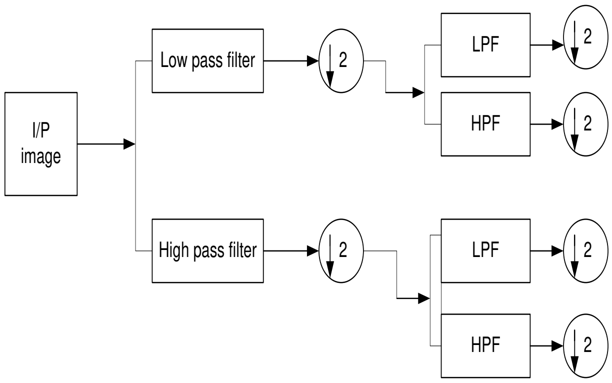

FIG.6. STRUCTURE OF DWT DECOMPOSITION

The figure 5 and 6 shows the structure of SWT and DWT detail coefficient and approximation coefficient of image Low-Low(L.L) Low-High(L.H.), High-Low(H.L.), High-High(H.H.) frequency component.

IV. ALGORITHM

1. Input Low Resolution image.
2. Apply DWT and SWT on input image.
3. Apply Bicubic interpolation with factor 4 and 2 to three high frequency subband images of DWT and SWT respectively.
4. Add interpolated high frequency subbands of SWT and DWT technique to get the estimated sub-bands.
5. Interpolate estimated subbands by factor α/4.
6. Apply IDWT to the interpolated HF subbands and LL band of SWT image to get high resolution image.

V. PERFORMANCE PARAMETER

Here Peak Signal to Noise Ratio (PSNR) is calculated to analyze quality of image.Table1 compares PSNR results of two proposed technique. Different types of images such as Lena, Elaine, Baboon, Peppers are tested by this algorithm. The PSNR calculation of two images, one original and reconstructed image, describes how far two images are equal.

PSNR in DB given as

$$PSNR\,(DB) = 10 \log_{10}\left(R^2/_{MSE}\right)$$

Where
R= peak value of the input image

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

M & N are the size of the images, M = no. of rows N= no. of columns and are the matrix element of the reconstructed image and the original image at (i,j)th pixel respectively. The result in table1 shows that proposed method1 is superior than method2.

Table1 .Observation Table

	PSNR(dB)	
Method/Image	Proposed Method1	Proposed Method2
Lena	29.89	39.64
Elaine	28.61	41.67
Baboon	28.69	47.67
Pepper	29.10	41.96

VI. RESULTS AND DISCUSSION

Figure7 and Figure 8 shows the low resolution input & high resolution output Lena image of method1& method2 respectively. Table 1 compares the PSNR performance of both DT-CWT & DWT, SWT technique. The result in table1 indicates that the DWT, SWT technique gives much better result as compared DT-CWT technique.Table1 shows that PSNR value is increased by 10dB using DWT, SWT technique than DT-CWT.

Original Image 128 x 128

High Resolution Image 512 x 512

Fig.7. method1 images

Original Image 128 x 128	High Resolution Image 512 x 512
	

Fig.8. method2 images

VII. CONCLUSION

This paper proposes two different methods to obtain high resolution images from low resolution images. Here both proposed methods are compared. PSNR table shows the superiority of proposed technique DWT,SWT .i.e The proposed technique DWT,SWT is much better than second technique DT-CWT. This work involves decomposition of low resolution image by using DWT which gives high frequency subbands. High frequency subbands are interpolated to increase their size. DWT loses some information due to interpolation process. This loss of information is corrected by SWT. Interpolated high frequency subbands and interpolated input image is combined by using inverse DWT(IDWT) to achieve the high resolution image. Both these techniques tested on standard matlab images, where PSNR result shows that maximum PSNR value using DT-CWT is 29.89 and by using DWT,SWT is 39.64 i.e. by using DWT,SWT technique PSNR value is increased by 9 to 10dB.

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