Color Image Super Resolution by Wavelet Transform using Interpolation and Fusion

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ABSTRACT:

In this paper we present an image super resolution scheme for enhancing digital color images. A novel proposed enhancement scheme is based on interpolation of the high frequency sub-bands is obtained with DWT and SWT wavelet transforms. In this scheme the DWT decomposed an image into four sub-bands, in that three sub-bands are high frequency sub-bands images have been interpolated. These high frequency sub-band coefficients are corrected by interpolation. The proposed bicubic interpolation is used in intermediate stage to find the high frequency sub-bands and it is more sophisticated than existing nearest neighbor and bilinear schemes. Objective of the proposed scheme is to improve the image super resolution, smoother edges and sharper image.

Key words: Image super resolution, DWT,SWT.

I. INTRODUCTION

The objective of image Resolution enhancement is to overcome the limitation of the image acquisition device or ill posed acquisition condition [1]. A Super Resolved image is useful for many fields. Resolution has been frequently referred as an important property of an image whether it's a satellite image or a medical image. These days satellite images are being used in different fields, so it is essential to have high resolution satellite images [1-2]. These images are affected by various factors such as absorption, scattering etc in the space. To have better perception of these images it is necessary to increase the resolution. Resolution enhancements of these images have always been a major issue to extract more information from them. Similarly the Medical image enhancement technologies have attracted much attention since advanced medical equipments were put into use in the medical field. Enhanced medical images are desired by a radiologist to assist diagnosis and interpretation because medical image qualities are 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 and the high level noise of a medical image.

Medical image Enhancement technologies have attracted so many new studies [4-5]. Images are being processed in order to obtain super enhanced resolution. Interpolation in image processing is a method to increase the number of pixels in a digital image. Interpolation has been widely used in many image processing applications, such as facial reconstruction [4], multiple description coding [5], and image resolution enhancement [6]–[8]. The interpolation-based image resolution enhancement has been used for a long time and many interpolation techniques have been developed to increase the quality of this task. There are three well-known interpolation techniques, namely, nearest neighbor, bilinear, and bicubic. Bicubic interpolation is more sophisticated than the other two techniques and produces smoother edges. The drawback of interpolation method is that, this method cannot do super resolution of single image since it cannot produce those high-frequency components that were lost during the image acquisition process. G. Anbarjafari and H. Demirel proposed a new technique for image Super Resolution by combining both the wavelet transform and interpolation. This technique reduces all the drawbacks of above mentioned techniques. However, applying interpolation in high frequency sub-bands introduces aliasing effects [10, 11]. The proposed technique also combines the wavelet transform and interpolation. This method uses stationary wavelet transform instead of discrete wavelet transform. The proposed method is tested with different types of wavelets & interpolation methods & results are compared.

II. RELATED WORK

Image super resolution enhancement in the wavelet domain is relatively new research topic and recently many existing algorithms have been proposed [4]-[6]. The wavelet transform technique is one of the best wavelet transform techniques used in image processing. Discrete Wavelet Transform (DWT) decomposed image into various sub-band images namely low-low (LL), low-high (LH), high-low (HL), and high-high (HH). The recent wavelet transform which has been used in various image processing applications such as stationary wavelet transform (SWT) [5]. The SWT is similarly to DWT but it does not used down-sampling the sub-bands will have the equal size as the input image.

The redundancy and shift invariance of the DWT mean that DWT coefficients are inherently interposable. One level DWT is used to decompose an input image into different sub-bands**.** Three high frequency sub-bands (LH, HL, and HH) contain the high frequency components of the input image. In the proposed technique, bi-cubic interpolation with enlargement factor of 2 is applied to high frequency sub-band images. Down sampling in each of the DWT sub-bands causes information loss in the respective sub-bands. That is why SWT is employed to minimize this loss. The interpolated high frequency sub-bands and the SWT high frequency sub-bands have the same size which means they can be added with each other. The new corrected high frequency sub-bands can be interpolated further for higher enlargement.

III. PROPOSED METHOD

The proposed image resolution enhancement techniques by using interpolation have some limitations loss is on its high frequency components that is the edges are smoothing caused by interpolation. To increase the image quality of the super resolved images preserving the edges is essential. This article proposes DWT has been employed in order to preserve the high frequency components of the image. The DWT means that it decomposed coefficients are inherently interposable. The correspondent one level DWT is used to decompose an input image into different sub-band images. In that four coefficients one is approximation image and remaining three high frequency sub-bands (LH, HL, and HH) have contain the high frequency components of the input image. In this project we propose bicubic interpolation with enlargement factor if 2 is applied to high frequency sub-band images. On those sub-bands we are applying the down sampling in each of the DWT sub-bands causes' information loss in the respective sub-bands. That's why SWT is employed to minimize these losses. The high frequency interpolated sub-bands and the SWT high frequency sub-bands have the same size which means that the same size can be added with each other. Then the corrected high frequency sub-bands can be interpolated for higher enlargement. It is known that the wavelet domain, the low resolution image is obtained by low pass filtering of high resolution image. Instead of using the low frequency sub-bands are contains less information than the original high resolution images; here we are using the input image for the interpolation of the low frequency sub-band images. The input image by N/2 and high frequency sub-bands by 2 and N in the intermediate and final interpolation stages respectively and then applies IDWT as illustrated in the fig1. If the output image getting sharper edges then directly apply the interpolation of the input image. Due to the fact of interpolation is isolated high frequency components are in high frequency sub-bands corrected by adding the high frequency sub-bands of SWT of the input image will preserve more high frequency components after the interpolation than interpolating input image directly.

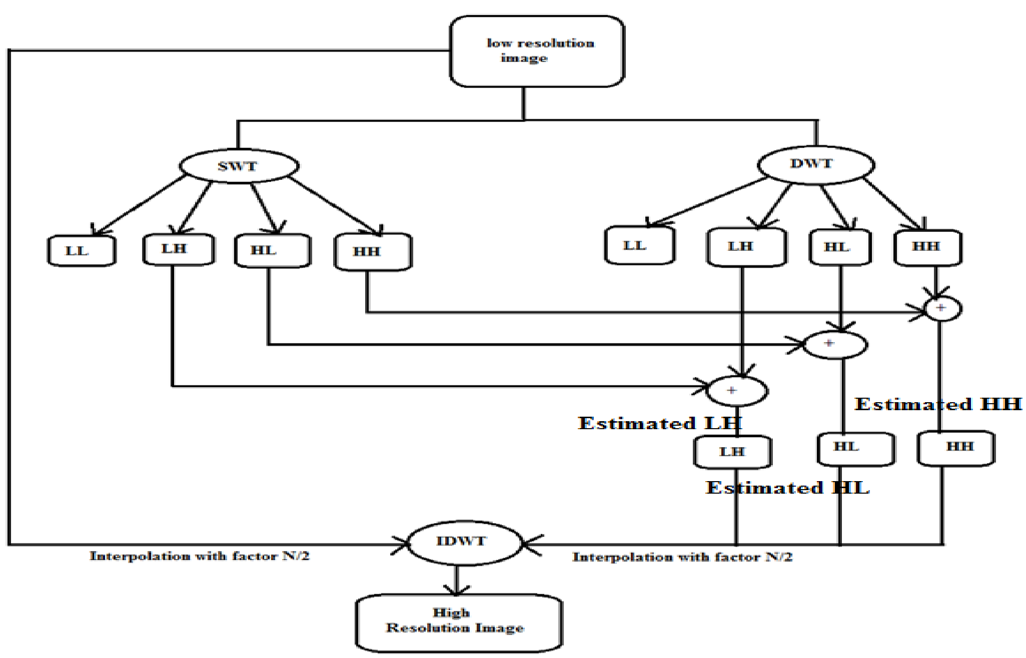

Fig.1. Image super resolution by using DWT and SWT based method.

From the Fig1. Shows approximation components are removed, but in this considered only high frequency components as well as lower frequency components.

This proposed scheme follows these steps:

- In the first stage an input low resolution image is generated from original image. Then original high resolution image is passed through a Gaussian low pass filter, it can separated only low frequency components of image. Then the image is down sampled row and column wise by a factor of 2.
- In the second stage we applied Discrete Wavelet Transform (DWT) and Stationary Wavelet Transform (SWT) is applied to the low resolution images on parallel. The low resolution image is decomposed into four sub-bands represented by LL (Low-Low), LH (Low-High), HL (High-Low), and HH (High-High).
- After that the Higher sub-bands of DWT are interpolated by a factor of 2 and added with the corresponding higher sub-band are obtained through the SWT decomposition.
- The estimated four coefficients are combined using IDWT (Inverse Discrete Wavelet Transform) to provide higher resolution image.

Performance Parameters

- MSE and PSNR

Not only for visual comparison to quantitative comparisons is confirming the superiority of the proposed method. Peak signal-to-noise ratio (PSNR) and root mean square error (RMSE) have been implemented in order to obtain some quantitative results for comparison. PSNR can be obtained by using the following formula:

$$PSNR = 10.log_{10}\left(\frac{C^2}{MSE}\right) \quad (1)$$

$$MSE = \frac{\sum_{x=1}^{M} \cdot \sum_{y=1}^{N} \left(I(x,y) - I'(x,y)\right)^2}{M.N} \quad (2)$$

Where c is the maximum fluctuations in the input image.

$$\text{RMSE} = \sqrt{\frac{\sum_{x=1}^{M} \cdot \sum_{y=1}^{N} \left(I(x,y) - I'(x,y)\right)^2}{M.N}} \quad (3)$$

SSIM (structural similarity) index is a method for measuring the similarity between two images. And SSIM is considered for measure the image degradation as perceived changes in structural similarity.

$$\text{SSIM}(x,y) = \frac{(2\mu_x \mu_y + C_1)(2\sigma_{xy} + C_2)}{(\mu_x^2 + \mu_y^2 + C_1)(\sigma_x^2 + \sigma_y^2 + C_2)}$$

IV. SIMULATION RESULTS

The proposed image super resolution method is tested on various images performance. Firstly these images are converted into their low resolution image through Gaussian down sample function and then DWT and SWT is applied to the low resolution image. The performance of the proposed method is compared by applying wavelets namely Haar, Db8, Sym4 and Sym8. Table 1 shows the results of the DWT and SWT based method and Table 2 shows the results of the proposed method for different wavelets in terms of PSNR and SSIM. It is clear from comparison the PSNR and SSIM of super resolution Image of proposed method is better as compare to DWT and SWT method.

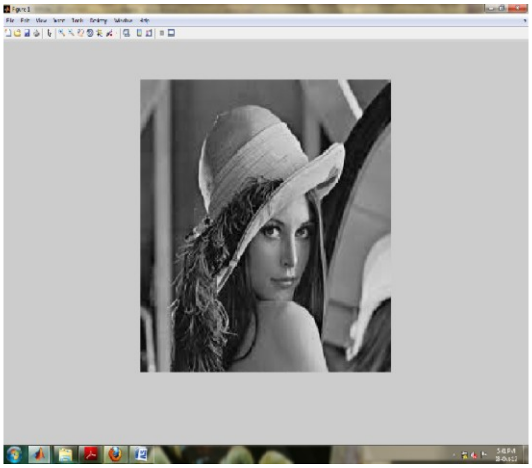

Fig2. Input image

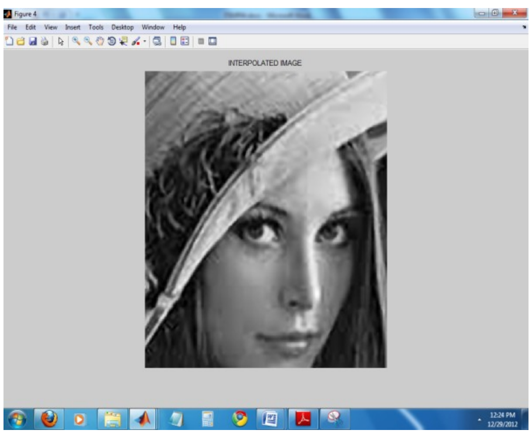

Fig.3. Interpolated Image.

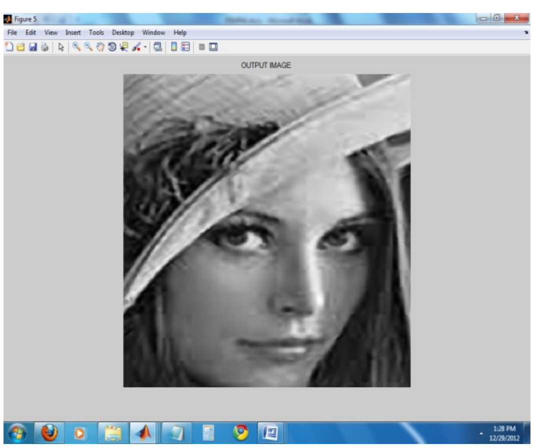

Fig.4. DWT-SWT based resultant image.

Tabel-I

Image	Interpolation	DWT-SWT
Lena MSE PSNR(db)	 65.4735 30.0041	 0.0544 60.0587
Cameraman MSE PSNR(db)	 56.4567 32.3456	 0.0456 62.4565

V. CONCLUSION

This paper has proposed a new image super resolution scheme based on interpolation of high-frequency sub-band images is obtained by DWT. This proposed scheme has been tested well-known benchmark images of PSNR, RMSE, SSIM and visual results of the superiority of the proposed scheme over the conventional state-of-art image super resolution schemes. In this proposed scheme the PSNR value is improved compared with standard cubic interpolation method.

In future we may try to improve resolution on SAR images, to get some techniques which provide more improvement in the PSNR, RMSE, and SSIM to get super resolution image and videos.

VI. REFERENCES

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