International Journal of Modern Trends in Engineering and Research
www.ijmter.com
e-ISSN No.:2349-9745, Date: 2-4 July, 2015

Discrete Wavelet Transform for image enhancement

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Abstract—in this correspondence we propose a technique for augmentation of image resolution based on wavelets which has a certain capability to analyze non-stationary signals. Satellite images are being used in many fields of research. One of the major issues of these types of images is their resolution. The discrete wavelet transform and unprocessed image is used to obtain interpolation of the high frequency sub-band images. In intermediate stage stationary wavelet transform is used to enhance the edges of image. The decomposition of input image to obtain frequency sub-bands is done by discrete wavelet transform. Then the high frequency sub-bands as well as the input image are interpolated. The high frequency sub-bands obtained by SWT are being used to modify estimated high frequency sub-bands. Then inverse discrete wavelet transform is used to combine all these sub-bands from which a new high resolution image is generated. The quantitative peak signal-to-noise ratio and enhanced visual features of the subject images shows the superiority of the proposed technique over the conventional bicubic interpolation, wavelet zero padding and bilinear interpolation based image resolution enhancement techniques.

Keywords- Image processing, Discrete wavelet transform, Bicubic Interpolation

I. INTRODUCTION

Resolution has been frequently referred as an important aspect of an image. Images are being processed in order to obtain more enhanced resolution. One of the commonly used techniques for image resolution enhancement is Interpolation. Interpolation has been widely used in many image processing applications such as facial reconstruction [1], multiple description coding [2], and super resolution [3]. There are three interpolation techniques, nearest neighbor, bilinear, and bicubic interpolation. Discrete wavelet transform is one of the recent wavelet transforms used in image processing. Decomposition of 2-D Image by using DWT is shown in figure 1. DWT decomposes an image into different sub-band images, namely (LL), (LH),(HL), and (HH). Another recent wavelet transform which has been used in several image processing applications is stationary wavelet transform. In short, SWT is similar to DWT but it does not use down-sampling, hence the sub-bands will have the same size as the input image. An important characteristic underlying the design of image processing systems is the significant level of testing & experimentation that normally required before arriving at an acceptable solution. This characteristic implies that the ability to formulate approaches & quickly prototype candidate solutions generally plays a major role in reducing the cost & time required to arrive at a viable system implementation.

There are no clear-cut boundaries in the continuum from image processing at one end to complete vision at the other. However, one useful paradigm is to consider three types of computerized processes in this continuum: low-, mid-, & high-level processes. Low-level process involves primitive operations such as image processing to reduce noise, contrast enhancement & image sharpening. Mid-level process on images involves tasks such as segmentation, description of that object to reduce them to a form suitable for computer processing & classification of individual objects. A mid-level process is characterized by the fact that its inputs generally are images but its outputs are attributes extracted from those images.

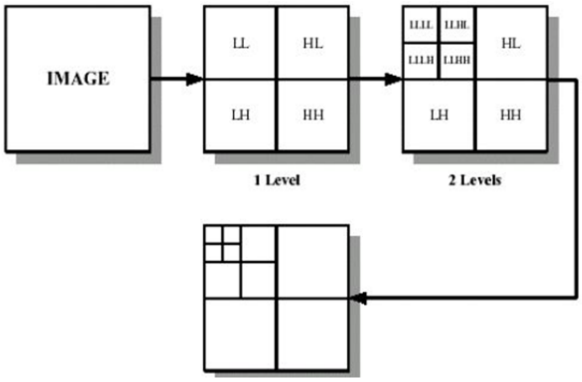

Figure 1.Wavelet decomposition of 2-D image.

We are proposing an image resolution enhancement technique which generates sharper high resolution image. The pro- posed technique uses DWT to decompose a low resolution image into different sub-bands. Then the three high frequency sub-band images have been interpolated using bicubic interpolation. The high frequency sub- bands obtained by SWT of the input image are being incremented into the interpolated high frequency sub-bands in order to correct the estimated coefficients. In parallel, the input image is also interpolated separately. Finally, corrected interpolated high frequency sub-bands and interpolated input image are combined by using inverse DWT to achieve a high resolution output image. The proposed technique has been compared with conventional and state-of-art image resolution enhancement techniques. The conventional techniques used are the following:

a. Interpolation techniques: Bilinear interpolation ;
b. Wavelet zero padding (WZP).

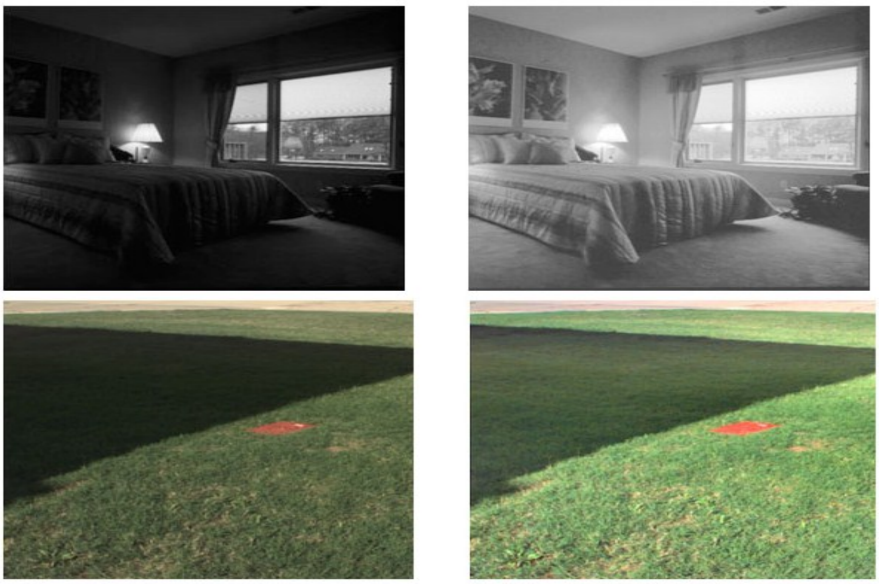

Figure 2. (a) Original image resolution(b) Augmented resolution image.

Figure 2.b) above shows the expected augmented resolution image obtained from given database

image having low resolution. According to the quantitative and qualitative experimental results, the proposed technique over performs the aforementioned conventional and state-of-art techniques for image resolution enhancement.

II. PROPOSED METHODOLOGY

In image resolution enhancement by using interpolation the main loss is on its high frequency components, which is due to the smoothing caused by interpolation. In order to increase the quality of the super resolved image, preserving the edges is essential. In this work, DWT has been employed in order to preserve the high frequency components of the image. The redundancy and shift invariance of the DWT mean that DWT coefficients are inherently interpolable. In this correspondence, one level DWT (with Daubechies 9/7 as wavelet function) is used to decompose an input image into different sub-band images. Three high frequency sub-bands (LH, HL, and HH) contain the high frequency components of the input image. In the proposed technique, bicubic 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.

III. RESULTS AND DISCUSSIONS

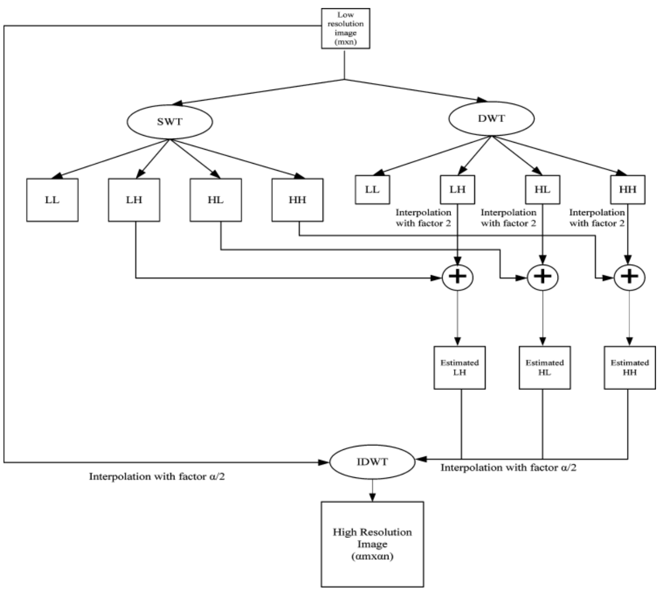

Figure 3.Block diagram of the proposed super resolution algorithm.

Note that the input low resolution images have been obtained by down-sampling the original high resolution images. In order to show the effectiveness of the proposed method over the conventional and state-of-art image resolution enhancement techniques, four test images (Taj, Man, Girl and Bhakti) with different features are used for comparison.

Visual inspection of picture of Taj shown in Figure 4 clearly indicates the superiority of proposed method.

Figure 4.(a) Bilinear interpolated image (b)Bicubic interpolated image (c) Proposed technique.

Table 1 compares the PSNR performance of the proposed technique using bilinear method, bicubic method, Wavelet Zero padding technique and proposed method by using DWT and SWT. Additionally, in order to have more comprehensive comparison, the performance of the super resolved image by using SWT only (SWT-SR) is also included in the table.

Table 1. PSNR performance using different methods

Sr. No.	Image Resolution Technique	Peak Signal to Noise Ratio (PSNR)			
		Baboon.jpg	Indoor .jpg	Outdoor. jpg	Taj.jpg
1	Bilinear method	27.44	29.641 9	25.428	25.275
2	Bicubic method	31.32	30.637 7	27.99	27.2008
3	Wavelet zero padding	33.52	35.45	33.3148	32.7094
4	Proposed method using DWT and SWT	34.70	35.961 9	33.5382	32.9819

IV. CONCLUSION

An image resolution enhancement technique based on the interpolation of the high frequency sub-bands obtained by DWT, correcting the high frequency sub-band estimation by using SWT high frequency sub-bands, and the input image. The proposed technique uses DWT to decompose an image into different sub-bands and then the high frequency sub-band images have been interpolated. The interpolated high frequency sub-band coefficients have been corrected by using the high frequency sub-bands achieved by SWT of the input image. An original image is interpolated with half of the interpolation factor used for interpolation the high frequency sub-bands. After- wards all these images have been combined using IDWT to generate a super resolved imaged. The proposed technique has been tested on well-known benchmark images, where their PSNR and visual results show the superiority of proposed technique over the conventional and state-of-art image resolution enhancement techniques.

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