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Image Resolution Enhancement using DWT and Spatial Domain Interpolation Technique

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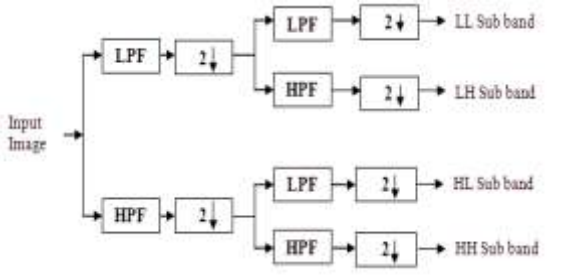
ABSTRACT
Image Resolution is one of the important quality metrics of images. Images with high resolution are required in many fields. In this paper, a new resolution enhancement technique is proposed based on the interpolation of four sub band images generated by Discrete Wavelet Transform (DWT) and the original Low Resolution (LR) input image. In this technique, the four sub band images generated by DWT and the input LR image are interpolated with scaling factor, α and then performed inverse DWT to obtain the intermediate High Resolution (HR) Image. The difference between the intermediate HR image and the interpolated LR input image is added to the intermediate HR image to obtain final output HR Image. Lanczos interpolation is used in this technique. The proposed technique is tested on well known bench mark images. The quantitative and visual results shows the superiority of the proposed technique over the conventional and state of art image resolution enhancement techniques in wavelet domain using haar wavelet filter.

Keywords: DWT, Lanczos Interpolation, Resolution.

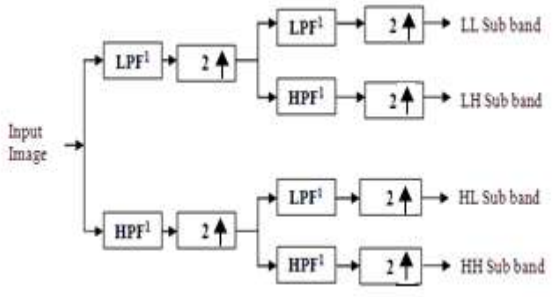
I. INTRODUCTION

Image Resolution is one of the most important quality metrics of images and videos. Images with higher resolution are required in most of the imaging applications, such as, medical imaging, video standard conversion, remote sensing and surveillance video. Resolution of an image stands for number of pixels in image. Image with more number of pixels has high resolution. The pixel resolution can be specified with the set of two positive integer numbers, where the first number is the number of pixel columns (width) and the second is the number of pixel rows (height), for example as 512 x 512. The most widely used technique for enhancing the image resolution is Interpolation. Fundamentally, Interpolation is the process of using known data to estimate values at unknown locations [1]. In Image processing, Interpolation is a method to increase the number of pixels in digital image. Conventional Interpolation Techniques which are commonly used are Nearest Neighbor, Bilinear, Bicubic and Lanczos. Resolution Enhancement techniques which are not based on wavelets suffer from the drawback of losing high frequency contents which results in blurring of the images [2]. Recently some techniques have been proposed [2]-[7] in wavelet domain for resolution enhancement. Using Wavelet Transform, spectrum can be obtained as a function of shift and scale. Hence, it is suitable for obtaining spatial as well as spectral resolution enhancement.

By using DWT, a HR Image can be decomposed into a LR Image and three wavelet detail images with horizontal, vertical and diagonal edge information at each scale by applying the 1D - DWT along the rows of the image first, and then the 1D - DWT along the column of the image. These four sub band images are referred to as LL, LH, HL, HH sub bands. The frequency components of these sub bands cover full frequency spectrum of the original image. Inverse DWT is used to obtain the original image using these four sub bands. The block diagram, representing the 2D – DWT process was given in Fig.1 and the corresponding output images for single level decomposition was given in Fig.2.



(a)



(b)

Fig. 1: (a) Single level decomposition of 2D DWT (b) Single level 2D Inverse DWT.

Fig. 2: Single level decomposition of lena image.

II. PROPOSED TECHNIQUE

In the proposed technique, the input LR image is decomposed into four sub band images using DWT and interpolated with lanczos kernel with scaling factor, α. Interpolated sub band images of LL, LH, HL and HH sub band images are represented with ILL, ILH, IHL and IHH respectively. Intermediate HR image is obtained by applying inverse DWT, with the interpolated sub band images ILL, ILH, IHL and IHH. The intermediate HR image is subtracted from interpolated input image with scaling factor, α to obtain the difference image, which is added to the intermediate HR image to get final output HR image. The input LR image was generated using two consecutive decomposition of original HR image using DWT with haar wavelet. The algorithm of the proposed technique is followed from Fig.3.

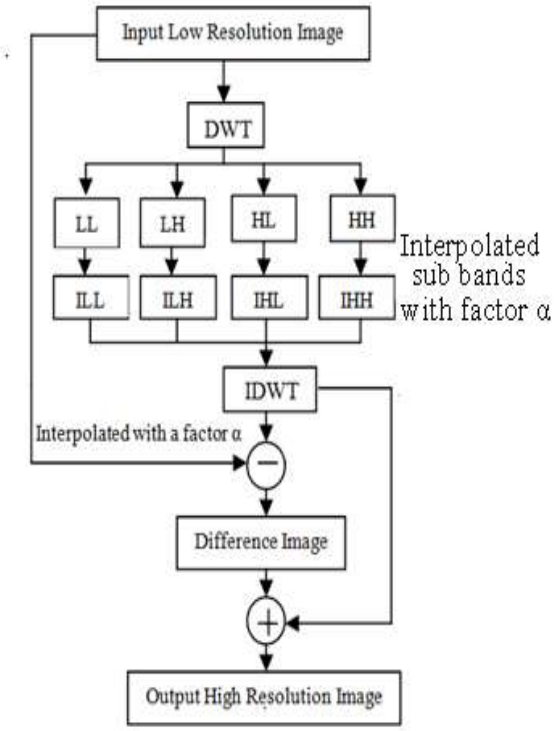


Fig.3: Proposed Image resolution enhancement technique using DWT and lanczos3 interpolation.

III. PERFORMANCE EVALUATION CRITERIA AND IMAGE QUALITY MEASURE

The resolution of the test image used in evaluation of image interpolation technique is known. After interpolation this resolution will change. To evaluate picture quality, the interpolated image will be compared with the original input image. In these circumstances input image and interpolated image cannot be compared because of different resolutions. Common approach is to start with an original HR image, generate a lower resolution version of original image by downscaling, and then use different interpolation methods to upscale low resolution image [8]. After that original and magnified HR images are compared to evaluate different techniques using different picture quality measures. Peak Signal to Noise Ratio (PSNR) is used for comparing different image resolution enhancement techniques.

PSNR is the ratio between the maximum possible power of a signal and the power of noise. PSNR is usually expressed in terms of the logarithmic decibel scale and they can be expressed as:

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

Where

- R is the maximum fluctuation in the input image (R=255, if images are represented with 8-bit gray

scale representation with radiometric resolution of 8-bit)

- MSE represents the Mean Square Error between the given original image, a and interpolated image, b with size M x N and is given by the formula

$$MSE = \frac{\sum_{i,j} (a_{i,j} - b_{i,j})^2}{MxN} \quad (2)$$

IV. RESULTS

The proposed technique was implemented using MATLAB R2014a software. The performance of proposed technique was compared with bicubic interpolation technique and wavelet based resolution enhancement techniques such as wavelet zero padding (WZP)[3], DASR method with bicubic interpolation and haar wavelet[5]. The proposed method gives better performance with lanczos3 interpolation and haar wavelet for unsigned 8 bit integer images. In Table 1, PSNR is compared for the existing and proposed method. The results demonstrate the superiority of the proposed technique over the above specified techniques with haar wavelet.

Table1: PSNR (in dB)for images, up scaled from 128x128 to 512x512 with scaling factor of 4.

Method / Image	PSNR (in dB)		
	Lena	Elaine	Baboon
Bicubic	26.86	28.93	20.61
WZP (Haar) [3]	26.67	28.06	21.11
DASR (bicubic+haar) [5]	27.07	27.94	18.06
DWT & SWT RE[6]	34.82	35.01	23.87
Proposed Method (lanczos3+haar)	34.87	42.12	24.81

(a) (b)

(c) (d)

(e) (f)

Fig. 4: Lena image upscaled from 128x128 to 512x512 with scaling factor of 4. (a) Original HR image (b) Generated input LR image, HR output image and the difference image from left to right, (c) and (d) of bicubic method, (e) and (f) of proposed technique.

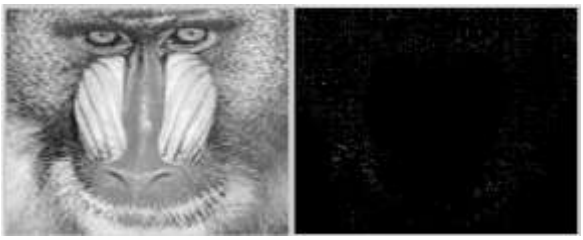
(a) (b)

(c) (d)

(e) (f)

Fig. 5: Elaine image upscaled from 128x128 to 512x512 with scaling factor of 4. (a) Original HR image (b) Generated input LR image, HR output image and the difference image from left to right, (c) and (d) of bicubic method, (e) and (f) of proposed technique.

(a) (b)



(c) (d)

Fig. 6: Baboon image upscaled from 128x128 to 512x512 with scaling factor of 4. (a) Original HR image (b) Generated input LR image, (c) HR output image and (d) The difference image of proposed technique.

The original HR image (512x512), input LR image (128x128), output HR image and difference image obtained by using bicubic and proposed technique are shown in Fig.4 and Fig.5. The subjective results show that the proposed method has less difference when compared with the above specified methods.

V. CONCLUSION

In this paper, a new technique for image resolution enhancement using DWT with haar wavelet and lanczos3 interpolation technique is presented. Performance evaluation criteria and image quality measure, PSNR is discussed in this paper. The PSNR value and visual results demonstrate the superiority of the proposed technique over DASR method with haar wavelet and bicubic interpolation.

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