International Journal of Electronic and Electrical Engineering.
ISSN 0974-2174, Volume 7, Number 6 (2014), pp. 555-560

http://www.irphouse.com

Interpolation based Resolution Enhancement of Digital Images using Wavelet Transform

Amit Sapehia

Division of Electronics and Communication Engineering Netaji Subhas Institute of Technology, University of Delhi New Delhi, India

Abstract

Resolution of image is one of principle characteristics of an image and in many applications it is required to enhance the resolution of the image without degrading the quality of image. In this paper, we propose a new resolution enhancement technique based on interpolation, discrete wavelet transform (DWT) and wavelet based image de-noising. The proposed algorithm requires DWT to decompose the low resolution input image into high frequency sub-band images (three detail and one approximate) which are interpolated individually. Following this we combine all these images to generate a noisy resolution enhanced image by using inverse DWT. In order to get a sharper and better image we apply wavelet based image de-noising to get a high resolution output image. The quantitative parameters like Entropy and Standard Deviation values and visual results show the efficiency and effectiveness of proposed algorithm.

Keywords: Resolution enhancement, interpolation, discrete wavelet transform (DWT), image coding, thresholding, wavelet transform based image de-noising, performance comparison.

1. Introduction

High resolution images have better appearance and quality as they have the capability to show even the finer details present in the scene. Resolution enhancement finds application in various fields like video resolution enhancement[1], feature extraction[2], and satellite image resolution enhancement [5]. Interpolation of a image results in increase in number of pixels in the image. In the proposed method bicubic interpolation is used as it produces smoother edges. Also DWT with daubechies basis function has been used to decompose the input image at level-1.The artifacts produced by interpolation and DWT are removed by wavelet based image denoising to produce a high resolution output image.

2. Interpolation and DWT Based Resolution Enhancement

In the proposed method firstly a low resolution input image (m X n) is produced from a high resolution image whose size is same as of output image (αm X αn), it is done in order to compare the output image of proposed method to the original high resolution image.

Once we have the low resolution input image (m X n) we use DWT level-1 decomposition which divides the entire spectrum of image into four sub-bands namely LL,LH, HL and HH. Now in the next step we apply bicubic interpolation of factor 2 to all these sub-band images individually. Now a difference image is produced by subtracting the approximate coefficient image (LL) from the low resolution input image, this difference image contains only the high frequency information of the input image.

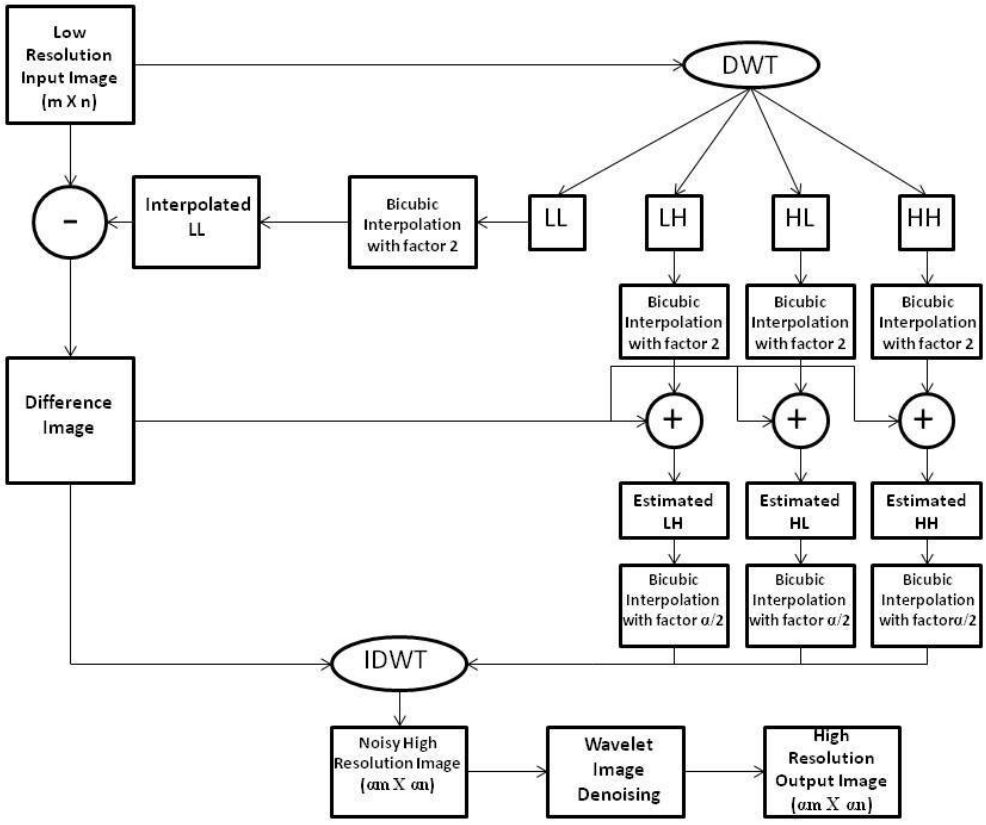

Fig. 1: Block Diagram of Proposed Algorithm.

In the following step the difference image of the previous step is added in the interpolated sub-images to give estimated LH,HL and HH. After applying bicubic interpolation of factor α/2 to estimated LH,HL,HH we find IDWT to get a noisy high resolution image (αm X αn). The main loss of an image after being resolution enhanced by applying interpolation is on its high-frequency components, which is due to the smoothing caused by interpolation. In order to take care of these artifacts

wavelet based image denoising has been applied to get a high resolution output image (αm X αn).

The goal of image denoising is to remove noise by differentiating it from the signal. We use the energy compactness property of wavelet transform in order to denoise the noisy high resolution image while preserving fine structures in the image.

3. Results and Discussion

The results after various steps in the algorithm are :

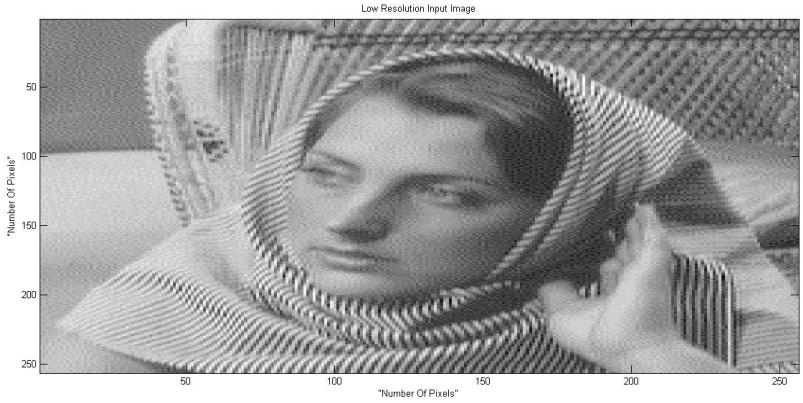

Fig. 2: Low Resolution Input Image(256 X 256)

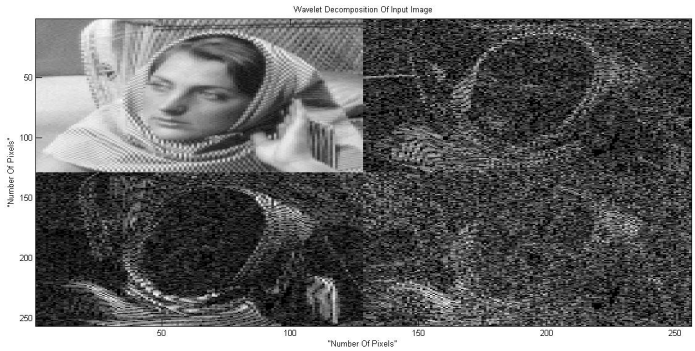

Fig. 3: Level-1 Wavelet decomposition of Input Image(LL,LH,HL,HH)

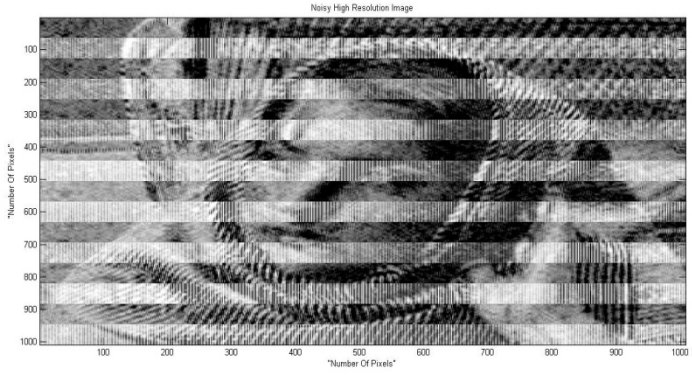

Fig. 4: Noisy High Resolution Image(1024 X1024),α = 4

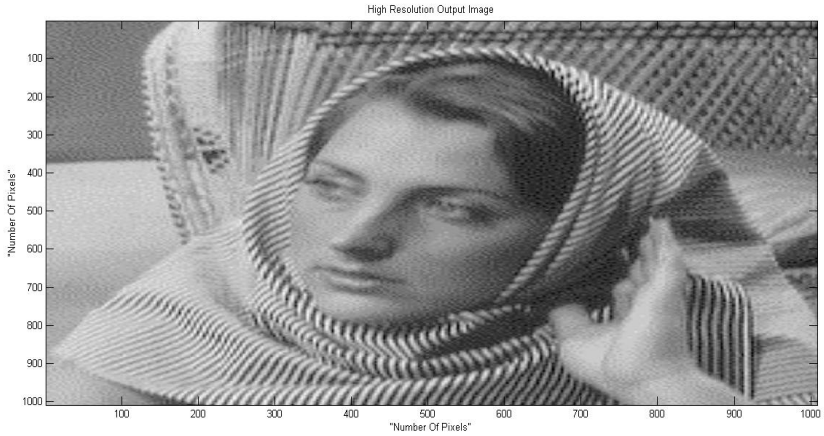

Fig. 5: High Resolution Output Image(1024 X 1024), α = 4.

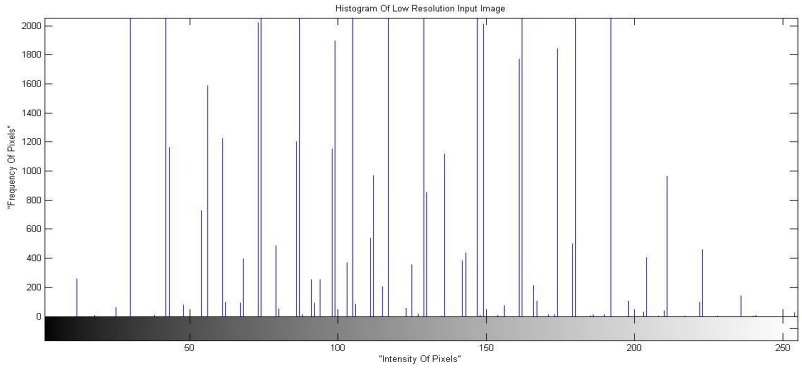

Fig. 6: Histogram of Low resolution Input Image(256 X 256)

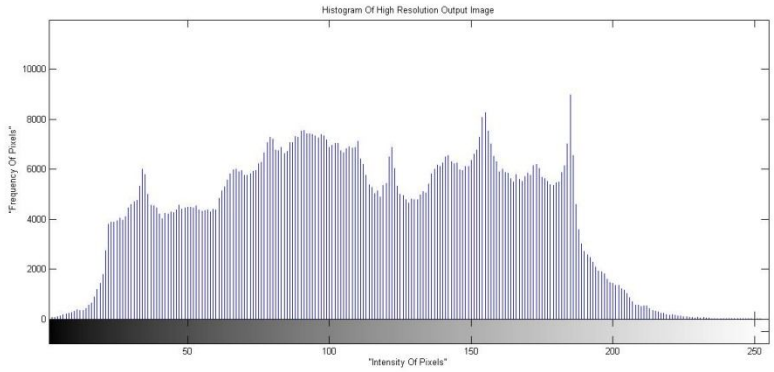

Fig. 7: Histogram of High resolution Output Image(1024 X 1024)

In order to compare the proposed method with already available methods such as WZP and CS based resolution enhancement[4], Demirel and Anbarzafari [5] various efficiency parameters used are Peak signal-to-noise ratio (PSNR) and mean square error (MSE).

$$PSNR = 10\, log_{10}(\frac{R^2}{MSE})$$

where R is maximum fluctuation in an image e.g in 8-bit image R is 255.

$$RMSE = \sqrt{\sum_{i,j} \frac{(I_{org}(i,j) - I_{out}(i,j)^2)}{(m\ X\ n)}}$$

Where, $I_{org}(i,j)$ is the original reference image used used to make low resolution input image. $I_{out}(i,j)$ is high resolution output image,(m X n) is the size of image.

METHOD	PSNR(db)	RMSE
Bilinear	35.41	4.36
WZP and CS RE[4]	30.22	4.11
Demirel and Anbarzafari[5]	35.91	3.66
The proposed method	36.10	3.48

The PSNR and RMSE results show that proposed method has superior results in comparison to conventional methods of resolution enhancement.

References

[1] H. Demirel, G. Anbarjafari, and S. Izadpanahi, "Improved motion-based localized super resolution technique using discrete wavelet transform for low resolution video enhancement," in *Proc. 17th EUSIPCO*, Edinburgh, U.K., Aug. 2009, pp. 1097–1101.

[2] T. Celik, C. Direkoglu, H. Ozkaramanli, H. Demirel, and M. Uyguroglu, "Region-based super-resolution aided facial feature extraction from low resolution video sequences," in *Proc. IEEE ICASSP, Philadelphia*, PA, Mar. 2005, vol. II, pp. 789–792.

[3] R. C. Gonzalez and R.E. Woods, Digital Image Processing. Englewood Cliffs, NJ: Prentice-Hall, 2007

[4] A. Temizel and T. Vlachos, "Wavelet domain image resolution enhancement using cycle-spinning," *Electron. Lett.*, vol. 41, no. 3, pp. 119–121,Feb. 3, 2005.

[5] H. Demirel and G. Anbarjafari, "Satellite image resolution enhancement using complex wavelet transform," *IEEE Geosci. Remote Sens. Lett.*, vol. 7, no. 1, pp. 123–126, Jan. 2010.

[6] http://www.mathworks.in