Analysis of Image Enhancement Techniques

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Abstract— Resolution is one of the most important characteristic of an image and it defines the quality of an image. Resolution in its most basic form can be defined as the number of pixels of an image. For proper processing, the image needs to have spatial, temporal and spectral resolution. Images from remote sensing devices especially satellite images undergo resolution degradation due to environmental changes, limitations in sensor characteristics, etc. It is thus necessary to improve these images for better visual interpretation and to make them suitable for further processing. Image enhancement is a crucial preprocessing step which is problem oriented and application specific. In this paper, satellite image resolution enhancement techniques based on the Wavelet domain like DWT, WZP and DWTSWT are compared. Wavelet Transform is an important field for the research in Image Processing. Image enhancement being a subjective process is compared using quantitative parameters like PSNR, MSE, MAE and SSIM.

Keywords— *Discrete Wavelet Transform (DWT), Stationary Wavelet Transform (SWT), Wavelet Zero Padding (WZP), Peak Signal to Noise Ratio (PSNR), Mean Squared Error (MSE), Mean Absolute Error (MAE), Structural Similarity (SSIM).*

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I. INTRODUCTION

Satellite images are used in various applications like weather monitoring and forecasting, disaster mitigation and planning, agricultural development, concealed weapon detection etc. These rapidly increasing applications require images with good spatial, spectral and temporal resolution. Satellite images usually suffer from resolution degradation due to atmospheric changes, poor illumination, sensor limitations etc. Thus image enhancement is essential. In image enhancement, the image is manipulated to make it more suitable than the original, for any given application [1]. Image enhancement techniques are traditionally classified into two domains, namely Spatial (time) and Transform (frequency) domain.

In spatial domain, the pixel values are directly manipulated to achieve the required enhancement [2]. Spatial domain techniques enhance the whole image uniformly which at times result in undesirable effects and these techniques cannot adequately enhance the edges. In other words spatial domain techniques only provide spatial resolution.

In many cases, the most prominent information is concealed in the frequency content of the signal [2]. In transform domain, the image is first transformed from time to frequency domain and then the transformed image is manipulated. Hence the high frequency components like edges are easily and effectively enhanced while the background or smooth regions of an image which contribute to the low frequency component are not adequately enhanced. Thus only spectral resolution is achieved using frequency domain techniques.

These traditional techniques thus do not provide simultaneous spatial and spectral resolution. Wavelet Transform is capable of providing both frequency and time resolution. Wavelet Transform is based upon small waves with varying frequency and limited duration called wavelets. Since higher frequencies are better resolved in time and lower frequencies are better resolved in frequency, the use of wavelets therefore ensure good time resolution at higher frequencies and good frequency resolution at lower frequencies [3]. Hence Techniques based on Wavelet Domain are solution for these drawbacks as they provide flexibility in analyzing the signal over the entire time range.

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II. DWT BASED ENHANCEMENT TECHNIQUE

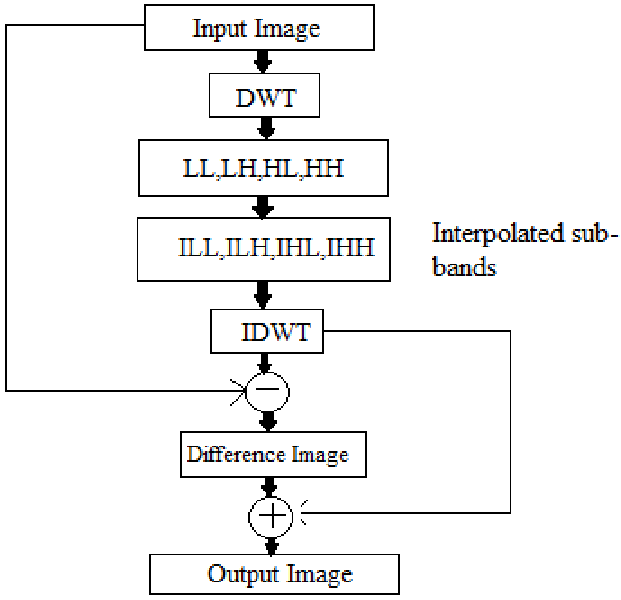

Fig. 1. DWT (Discrete Wavelet Transform)

Discrete wavelet transform (DWT) is a technique where the signal is discretely sampled and is split into sub bands. It is widely used for image interpolation[4][5]. DWT is technique of resolution enhancement where the input image is decomposed into four sub bands and interpolation is applied. Haar wavelet is used for both analysis and synthesis. Bicubic interpolation helps in getting more number of samples of all the sub bands LL,LH,HL,HH. Interpolation factor used is 2 and it is represented as ILL, ILH, IHL and IHH respectively. IDWT of interpolated sub bands is taken. This is an intermediade output. Later it is subtracted from low resolution input image and this difference image is added to the intermediate output which gives the final enhanced image. This addition of difference image is to retain the background information which is actually the LL content.

III. WZP BASED ENHANCEMENT TECHNIQUE

In this technique the Discrete Wavelet Transform of the input image is taken to obtain the sub bands (LL,LH,HL and HH). Then a set of zero valued elements is added at the end of a time-domain sequence in place of the high frequency components [6]. Zero Padding increases the illumination of the image by assuming the LL subband to be low resolution image itself and the high frequency sub bands consisting of edge information to be zero matrices of the same size as that of the input image. To obtain the final output image ,inverse transform of the input low resolution image and the zero valued high frequency subbands are taken. Hence the input image is low frequency approximation of the high resolution output image. As there is a loss of data due to the exclusion of high frequency components, the parametric analysis show poor results for this technique.

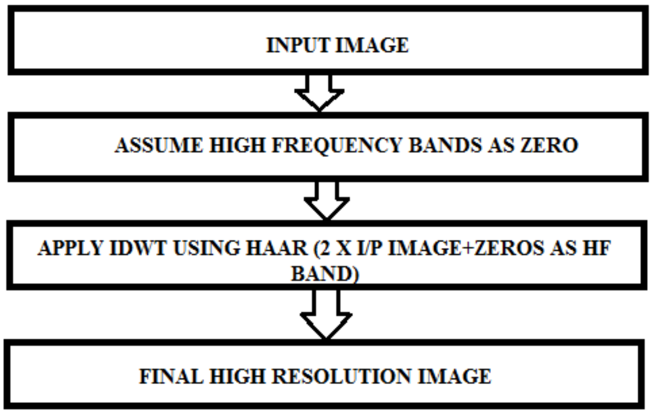

Fig.2. WZP (Wavelet Zero Padding)

IV. DWT-SWT BASED ENHANCEMENT TECHNIQUE

DWT has blurred High frequency components due to which the resultant image has higher illuminated background with unclear edges (High frequency component). This occurs due to the down sampling in each sub band. In order to minimize this effect, SWT is employed. SWT decomposes the image into four sub bands similar to DWT but without down sampling. Down sampling of the image in DWT reduces the size of the image to half of its original size which leads to loss of data [1]-[3]. Thus, there is a need of interpolation. The size of the SWT sub bands and the interpolated DWT sub bands is same and hence is matrix compatible. The Estimated coefficients (ELH, EHL and EHH) are obtained by adding higher order (LH, HL and HH) SWT and Interpolated DWT sub bands. Then the inverse transform of the input image is taken with the estimated coefficients to get the final high resolution image. The LL sub band has only the low frequency components of the original input image and hence instead of LL sub band, original Low resolution input image is used for taking the inverse transform (IDWT) to enhance the quality of the image.

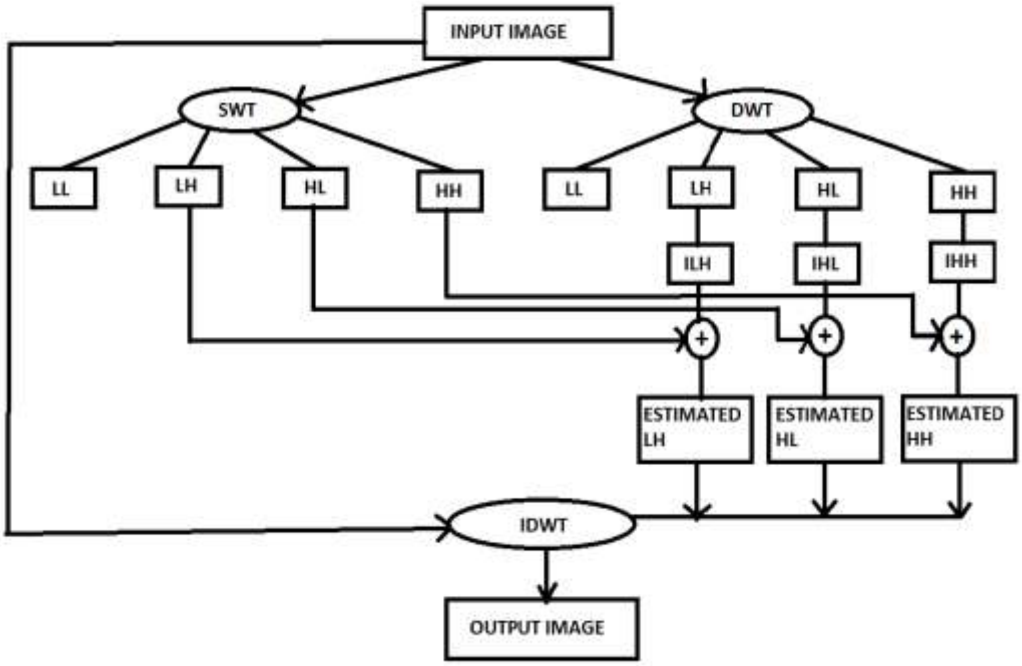

Fig.3. Discrete-Stationary Wavelet Transform

V. RESULT AND DISCUSSIONS

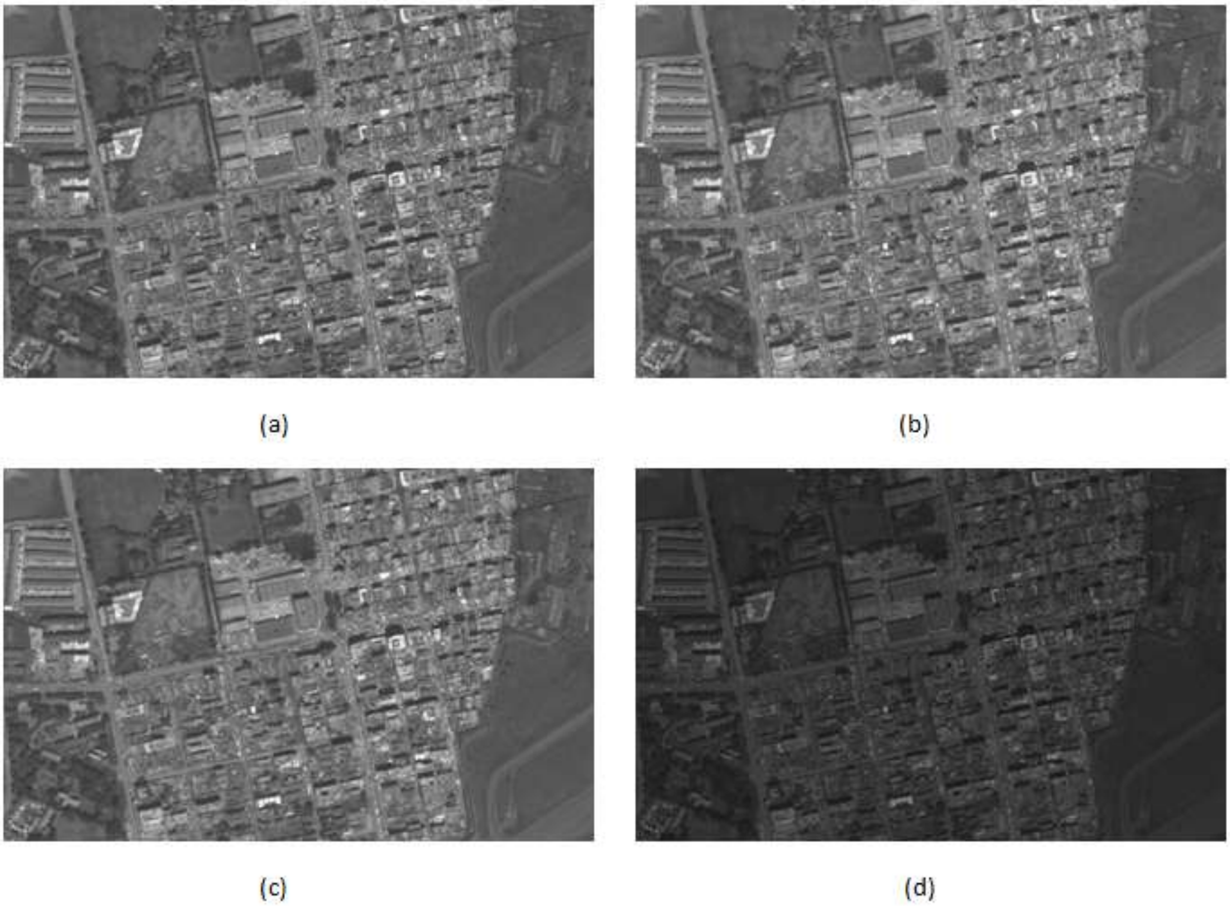

Fig.4 (a) Input LR3 (b) Discrete Wavelet Transform (DWT)
(c) Wavelet Zero Padding (WZP) (d) Discrete-Stationary Wavelet Transform (SWT)

TABLE I.

PSNR					
Method/Image	***LR1***	***LR2***	***LR3***	***LR4***	***LR5***
DWT	28.87	30.65	31.44	30.40	30.03
DWTSWT	54.07	74.58	77.83	53.31	51.58
WZP	31.21	33.60	33.18	31.42	31.18

TABLE II.

MSE					
Method/Image	***LR1***	***LR2***	***LR3***	***LR4***	***LR5***
DWT	84.94	56.47	47.04	59.75	65.14
DWTSWT	0.26	0	0	0.31	0.46
WZP	49.65	28.60	31.53	47.22	49.94

TABLE III.

MAE					
Method/Image	***LR1***	***LR2***	***LR3***	***LR4***	***LR5***
DWT	12.43	6.66	6.04	6.95	7.95
DWTSWT	0.03	0	0	0.03	0.04
WZP	5.67	3.24	3.54	5.08	5.43

TABLE IV.

SSIM					
Method/Image	***LR1***	***LR2***	***LR3***	***LR4***	***LR5***
DWT	0.9641	0.6546	0.9891	0.9895	0.9790
DWTSWT	0.7052	0.7213	0.6991	0.7064	0.7012
WZP	0.9558	0.7562	0.9940	0.9891	0.9867

All the three techniques have been applied and tested on 5 different Low Resolution (LR) satellite images. PSNR value should be as high as possible where as MSE and MAE values should be as low as possible. SSIM has to be in the range of 0-1 where, 0 indicates no similarity and 1 indicates perfect similarity. Thus SSIM value should be close to 1. On the basis of this, the techniques can be compared effectively and accurately. From the tables of all the parameters, it is clear that DWT-SWT shows the best performance on all the images. The images shown above are the outputs of one of those five LR images. These techniques can work on any satellite image with any size using any wavelet.

VI. CONCLUSION

In this paper, resolution enhancement techniques namely, DWT, WZP and DWT-SWT have been discussed and evaluated based on benchmark image quality metrics like PSNR, MAE, MSE and SSIM. The results indicate the superiority of DWT-SWT techniques over the other aforementioned techniques and the visual perceptions prove the same. There is still a lot of scope for optimization and adaptation of the techniques available in the literature to different sensor images.

REFERENCES

[1] Rafael C Gonzalez, Richard E.Woods, “ Digital Image Processing (Third Edition),” Pearson Education India

[2] Ms.Seema Rajput and Prof.S.R.Suralkar, “Comparative Study of Image Enhancement Techniques,” IJCSMC, Vol. 2, Issue. 1, January 2013, pg.11 – 21.

[3] Robi Pollikar, “ The Wavelet Tutorial-Fundamental Concepts and an Overview of Wavelet Theory ”

[4] Hasan Demirel and Gholamreza Anbarjafari “Discrete Wavelet Transform-Based Satellite Image Resolution Enhancement,” IEEE TRANSACTIONS ON GEOSCIENCE AND REMOTE SENSING, VOL. 49, NO. 6, pp. 1997-2004 JUNE 2011.

[5] Mrs. G. Padma Priya, Prof. T. Venkateswarlu, Image Resolution Enhancement using DWT and Spatial Domain Interpolation Technique , Int. Journal of Engineering Research and Applications , Vol. 6, Issue 2, (Part - 3) February 2016, pp.93-96.

[6] Shashi Vardhan Naidu, Akanksha Garg, Hussein Yahia, Dharmendra Singh, “A Comparison of Wavelet Based Techniques for Resolution Enhancement of moderate resolution satellite images”, National Conference on Recent Advances in Electronics & Computer Engineering, RAECE -2015, Feb.13-15, 2015, liT Roorkee, India

[7] Hasan Demirel and Gholamreza Anbarjafari, “IMAGE Resolution Enhancement by Using Discrete and Stationary Wavelet Decomposition,” in IEEE TRANSACTIONS ON IMAGE PROCESSING, VOL. 20, NO. 5, MAY 2011. pp 1458-1460.

[8] Vasileios Syrris, Stefano Ferri, Daniele Ehrlich, and Martino Pesaresi, Image Enhancement and Feature Extraction Based on Low-Resolution Satellite Data, IEEE JOURNAL OF SELECTED TOPICS IN APPLIED

EARTH OBSERVATIONS AND REMOTE SENSING, VOL. 8, NO. 5, MAY 2015 .pp 1986-1995.

[9] K. Narasimhan, V. Elamaran, Saurav Kumar, Kundan Sharma and Pogaku Raghavendra Abhishek, "Comparison of Satellite Image Enhancement Techniques in Wavelet Domain,"Research Journal of Applied Sciences, Engineering and Technology 4(24): 5492-5496, 2012.

[10] Dr. Muna F. Al-Samaraie1 and Dr. Nedhal Abdul Majied Al Saiyd, "Colored Satellites Image Enhancement Using Wavelet and Threshold Decomposition," IJCSI International Journal of Computer Science Issues, Vol. 8, Issue 5, No 3, September 2011.

[11] Gilbert Strang, Truong Nguyen, "Wavelets and Filter Banks", Wellesley-Cambridge Press.

[12] Michel Misiti, Yves Misiti, Georges Oppenheim, Jean-Michel Poggi, "Wavelet Toolbox- for use with MATLAB".