

## Super Resolution of Satellite Images Using Wavelet Based Edge Extraction through Sparse Representation

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### Abstract

In this research paper a super-resolution (SR) image is generated from low resolution satellite image. By using high frequency (HF) as intermediate stage, sharper image can be generated. Interpolation is performed between satellite portrait and HF sub bands through the discrete wavelet transform which preserves edge. Sparse signal is obtained by applying sparse mixing weights to low resolution (LR) image. Lanczos interpolation is used to avoid artifacts generated in an image. High resolution (HR) image is obtained by using all bands and inverse DWT is performed. Experimental results proves that proposed method has superior performance over existing methods in terms of intension criteria and skewed perception improving the image resolution. The quantitative PSNR (peak signal to noise ratio), RMSE (root mean square value), and CC (correlation coefficient) are calculated for satellite images. The proposed technique i.e., super resolution using wavelet domain interpolation with edge extraction and sparse representation (SR-WDIEE-SR) has got better values compared to DWT (Discrete wavelet transform).

**Keywords:** Super Resolution (SR), High Resolution (HR), Edge Extraction, Lanczos Interpolation.

### Introduction

The images obtained from medical, optical, and radar is seen on electron microscopy and high definition television, obtained from electronic sensors. Image enhancement techniques are applied to low resolution images to get high resolution images. This algorithm is preprocessing technique used in many applications such as satellite image processing, radar, and optical. Whenever image enhancement is done, the drawback is some noise is added. This noise is to be eliminated by using some denoising algorithms.

SR algorithms cost is less compared to other sensors used to increase the resolution of images [1], [2]. Recently many SR algorithms have been proposed [3]. The wavelet based sparse mixing plays

very important role in image enhancement of satellite images. Spatial and spectral information of satellite image is enhanced by this proposed algorithm [4].

The major difference between existing SR algorithms and proposed novel SR algorithm exists in mutual interpolation by lanczos [5], [6] and nearest neighbor interpolation (NNI) to wavelet transform high frequency sub bands. Out of these interpolation techniques lanczos interpolation is used because it has got many merits compared to others. It reduces ringing, sharpness and aliasing. It also detects edges and linear features. Edge extraction is done by DWT and adaptive LR image is computed by sparse representation of low frequency sub bands. NLM is used to avoid artifacts. Loss of low frequency results noise. The noise present in LL sub band is eliminated by NLM (non local mean) filter [7]. Finally, all sub bands are combined via inverse DWT. The output is super resolution image in terms of objective and subjective perception.

To give reason for that the new algorithm called super resolution using wavelet domain interpolation with edge extraction and sparse representation (SR-WDIEE-SR) has real compensation we have compared the proposed SR algorithm with other similar algorithms, Discrete Wavelet Transform-based Satellite Image Resolution Enhancement [8].

### Materials and Methods

Many interpolation techniques are used for super resolution algorithms such as nearest neighbor, bicubic, and bilinear. All these techniques lead to smoothing of edges which in turn leads to blurring effect in images. They cause loss of high frequency components. As low frequency components leads to smoothing and blurring. So DWT preserves high frequency components. The DWT reduces blurring effect in images. So it is most widely used for image enhancement and image denoising techniques. Analysis filters has low pass and high pass filters. The low pass filter reduces noise and the high pass filter preserves edges. Low pass filter preserves coarse information; whereas high pass will preserve fine information in an image [9]. The low resolution

satellite portrait of size 512\*512 is processed by DWT as shown in Fig.1, which divides the portrait into 4 sub bands named as LL (AV), LH (HE), HL (VE), and HH (DE) sub bands. LL contains approximate version of input image (AV), LH contains horizontal edges (HE), HL contains vertical edges (VE), and HH contains diagonal edges (DE).

AV, HE, VE, and DE are interpolated by bicubic interpolation. Difference of input image and interpolated AV image is taken. This difference is added to HE, VE, and DE sub bands. Finally inverse DWT is applied to all these sub bands. The output is high resolution image [10].

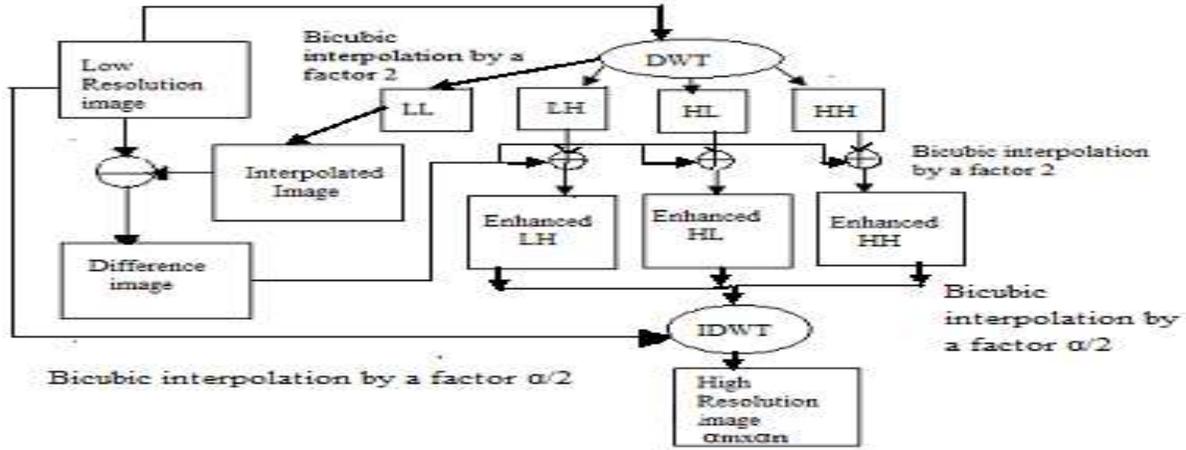


Fig. 1. Block Diagram of DWT

The satellite image is downloaded from google earth. It has been cropped to 512\*512, which is standard size. MATLAB software is used to process the satellite image for both DWT and SR-WDIEE-SR techniques. The proposed technique is super resolution using wavelet domain interpolation with edge extraction and sparse representation (SR-WDIEE-SR). Here a modified SR-WDIEE-SR is used to get super resolution of satellite images. The image is decomposed into four sub bands such as AV, HE, VE, and DE sub bands. Lanczos interpolation is applied to all the sub bands with a scaling factor of  $\alpha$ . The following are the steps given for the proposed algorithm.

Step 1: To suppress the noise, NLM filter is used for LL sub band. 1-D interpolation is used in a given direction  $\theta$  to calculate LR image and then subsequent calculation of the new samples along the oversampled rows, columns, or diagonals. Finally, the algorithm computes the missing samples along the direction  $\theta$  from the previously calculated new samples, where the entire sparse process is performed with the Lanczos interpolation (factor  $\alpha = 2$ ), reconstructing the AV sub band.

Step2: Sparse representation of AV band with a factor  $\alpha$  is generated in step 2a. Difference of input image and AV is taken. AV is approximate version of input satellite image. Then nearest neighbor interpolation is used to which the difference image is added in step 2b. The lanczos filter is a sinc filter which extracts edges in step 2c. Edge extraction from

step 2c is added to second nearest neighbor interpolation high frequency sub bands in step 2b. Inverse DWT is applied to modified AV sub band along with three high sub bands. The output is super resolution image as shown in Fig.2.

To preserve edge information of HF sub bands edge extraction is calculated by the formula as follows

$$E = \sqrt{HE^2 + VE^2 + DE^2} \quad (1)$$

In this algorithm edges are preserved by the high frequency sub bands. These high frequency sub bands play vital role in preserving edges. HE, VE, and DE are high frequency sub bands. Level 1 decomposition is used. We can go for level 2 and level 3 decomposition is used which depends on our requirement.

In this algorithm the AV sub band is not directly considered as it is approximated version of input image. The difference image is the modified AV which is added to remaining 3 high sub bands. By doing so, contrast of original image is increased.

DWT is mainly used for preserving high frequency sub bands which are affected while performing interpolation techniques. The loss of high frequency components leads to blurring effect.

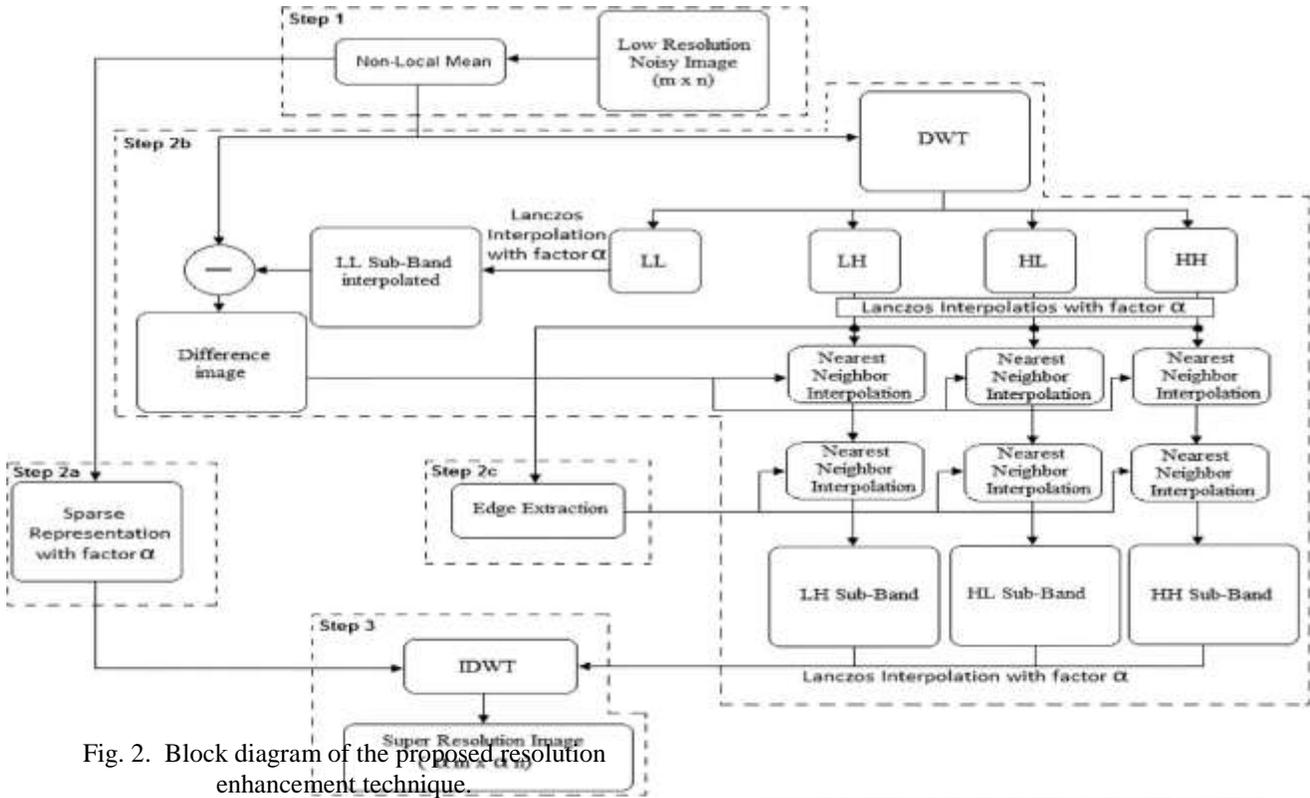


Fig. 2. Block diagram of the proposed resolution enhancement technique.

**Results and Discussions**

Fig.3 is the input satellite image of standard size 512\*512. The results for DWT and SR-WDIEE-SR are shown in Fig.4, and Fig.5. The PSNR, RMSE, and CC are calculated for DWT and SR-WDIEE-SR. Proposed method contrast has been increased compared to DWT method. SR-WDIEE-SR technique has got PSNR of 30.4299 dB and RMSE of 7.7045. The proposed method has better values in terms of quantitative parameters compared to DWT as shown in TABLE I. Simulation is carried out by MATLAB software.

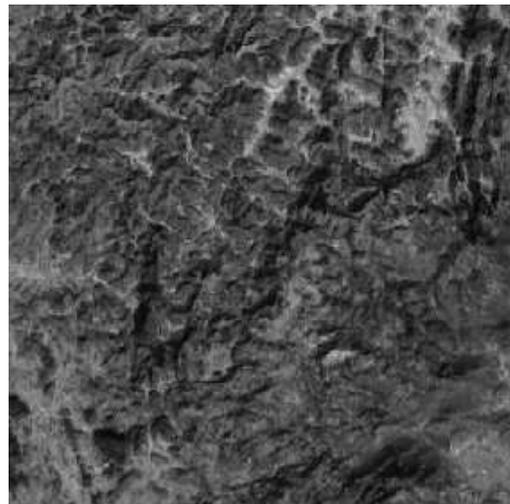


Fig.3. Low resolution input satellite image



Fig.4. super resolution image using DWT

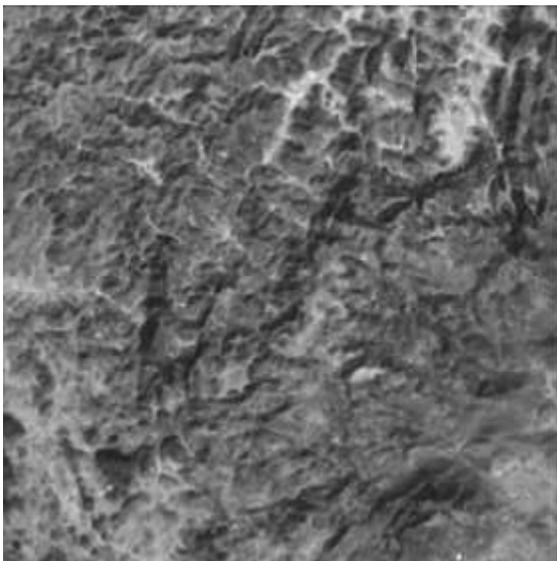


Fig.5. super resolution image using SR-WDIEE-SR

TABLE I

Enhancement using SR-WDIEE-SR techniques

<i>ALGORITHM</i>	<i>PSNR</i>	<i>RMSE</i>	<i>CC</i>
<b>DWT</b>	26.6611	11.4721	0.7373
<b>SR-WDIEE-SR</b>	30.4299	7.7045	0.9505

**Conclusion**

In this research paper, a new resolution-enhancement method based on the sparse based interpolation of the HF sub band images in the discrete wavelet domain has been implemented. This proposed technique (SR-WDIEE-SR) has superior performance in terms of peak signal to noise ratio, root mean square value and correlation coefficient when compared to DWT method. Experimental results highlight the superior performance of the proposed algorithm in terms of objective criteria, as well as in the subjective perception via the human visual system, in comparison with other conventional methods.

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