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Satellite Image Resolution Enhancement using Dual-tree Complex Wavelet Transform and Non Local Mean

Dhiraj Nehate [1], Prof. P.A. Salunkhe [2]

[1] PG student, Electronics and Telecommunications, Mumbai University, Mumbai, India
[2] Professor, Electronics and Telecommunications, Mumbai University, Mumbai, India

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Abstract - *Resolution enhancement (RE) schemes (which are not based on wavelets) suffer from the Disadvantage of losing high-frequency contents (which results in blurring). The discrete-wavelet-transform-based (DWT) RE scheme generates artifacts (due to a DWT shift-variant property). A wavelet-domain approach based on dual-tree complex wavelet transform (DT-CWT) and nonlocal means (NLM) is proposed for RE of the satellite images. A satellite input image is decomposed by DT-CWT (which is nearly shift invariant) to obtain high-frequency sub-bands. The high-frequency and the low-resolution (LR) input image are interpolated using the Lanczos interpolator. The high-frequency sub-bands are passed through an NLM Filter to cater for the artifacts generated by DT-CWT (despite of it's nearly shift invariance). The Filtered high-frequency sub-bands and the LR input image are combined using inverse DT-CWT to obtain a resolution-enhanced image. Objective and subjective analyses reveal superiority of the proposed technique over the conventional and state-of-the-art RE techniques.*

Key Words: **Dual-tree complex wavelet transform (DT-CWT), *Lanczos interpolation*, resolution enhancement (RE), shift-variant**

1. INTRODUCTION

In the Recent years there is increased in the demand for best quality images in the various applications such as medical, astronomy, object recognition. Satellite images are used in diverse areas such as monitoring the processes on the Earth's surface, discovery of changes in atmosphere; measuring as well as estimating geographical, biological and physical parameters, etc. The resolution of these images is extremely significant to obtain information from satellite images so it plays a main role in satellite image enhancement. And the Image Enhancement is a process of obtaining a high quality or high resolution image from low quality otherwise low resolution satellite image, for supplementary processing of an image, such as analysis, detection, segmentation along with recognition [2]. It is an essential step in image processing of satellite images. Image resolution enhancement is also widely useful for satellite image applications which contain bridge recognition, building construction in GPS technique. For image enhancement method there are two domains has been occupied into consideration one is image domain as well as transform domain. Transform domain conclude which transformations used in the Enhancement. Image interpolation is usually used resolution enhancement scheme for different applications. Image interpolation is the process of using recognized more data to approximation values at unknown locations. Interpolation method select new pixel from surrounding pixels. Mostly there are two types of interpolation algorithms.

1. Adaptive algorithm- This algorithm changes depending on what they are interpolating.
2. Non adaptive algorithms- contain linear interpolation algorithms

Linear interpolation includes Adjacent, bilinear, bicubic interpolation. But images obtained by these linear interpolation technique produces numerous artifacts similar to blurring, blocking etc. To avoid these problems non linear interpolation algorithms are intended for Resolution Enhancement.

1.1 Dual-tree Complex Wavelet Transform

This method, dual-tree CWT (DT-CWT) [4] [8] is used to decompose an input image into different sub-band images. In this method direction selective filters are used to generate high frequency sub-band images where filter demonstrate peak magnitude responses in the existence of image features oriented at angle +75, +45, +15, -15, -45 and -75 degrees, respectively [9]. Subsequently six complex valued images are interpolated. Once interpolated, combine all images to create a new high-resolution image by using inverse DT-CWT. Resolution is achieved [8] by using directional selectivity provided with the CWT, where the high-frequency subbands contribute to the sharpness of the high-frequency details. Finally IDT-CWT used to join all these images to construct resolution enhanced image.

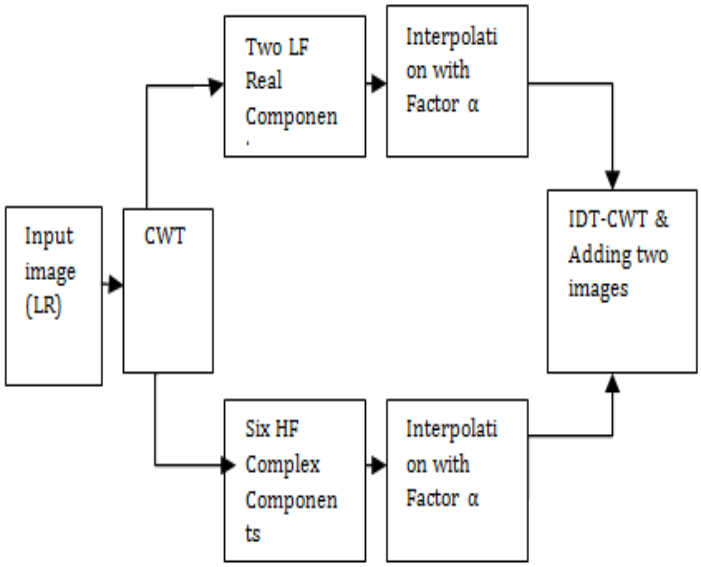

Fig 1.Block Diagram of DT CWT

Where *m* is the frame index, moreover *N* represents the neighborhood of the pixel at location (*p*, *q*).

K values are the filter weights, i.e.,

$$K(r,s) = \exp\{-\|V(p,q) - V(r,s)\|/2\sigma^2\} * f(\sqrt{(p-q)^2 + (q-s)^2 + (m-1)^2} \quad \ldots(2)$$

Where *V* is the window [typically a square window centered on the pixels *Y* (*p*, *q*) with *Y* (*r*, *s*)] of pixel values from a geometric neighborhood of pixels *Y* (*p*, *q*) as well as *Y* (*r*, *s*), *σ* is the filter coefficient, *f* (.) is a geometric distance function. *K* is inversely proportional to the distance between *Y* (*p*, *q*) and *Y* (*r*, *s*).

1.2 NLM Filtering

The NLM filter which is an extension of neighborhood filtering algorithms and it is based on the assumption that image content is likely to replicate itself within some neighborhood and in neighboring frame. It computes de-noised *x* (*p*, *q*) with the weighted sum of the adjacent pixels of *Y* (*p*, *q*) (within frame and in the neighboring frames). This characteristic provides a way to estimate the pixel value from noise contaminated images. In a 3-D NLM algorithm, the estimate of a pixel at point (*p*, *q*) is

$$X(p,q) = \frac{\sum_{m=1}^{M} \sum_{(r,s)\in N(p,q)}^{0} Y_m(r,s) K_m(r,s)}{\sum_{m=1}^{M} \sum_{(r,s)\in N(p,q)}^{0} Km(r,s)} \quad \ldots(1)$$

2. Flow of proposed technique

Input Image:-

Satellite Input Image Is Capture from Satellite Imaging Corporation Web Page .Satellite is Low Resolution Image

Preprocessing:-

In processing the resize the image into low resolution Input image (128*128)

Multilevel Dual Tree Complex Wavelet Transform:-

The two levels Dual Tree Complex Wavelet Transform are used. In multilevel DT-CWT decomposed the low resolution input image in diff.sub band .the sub-bands separated into image coefficient & Wavelet coefficient sub band. The 12 sub band are produce by multi level DTCWT .2 D DWT are used

King Q filter DTCWT:-

Q filter improved the Orthogonality & Symmetric Properties of the filter bank. Analysis & analysis Filter

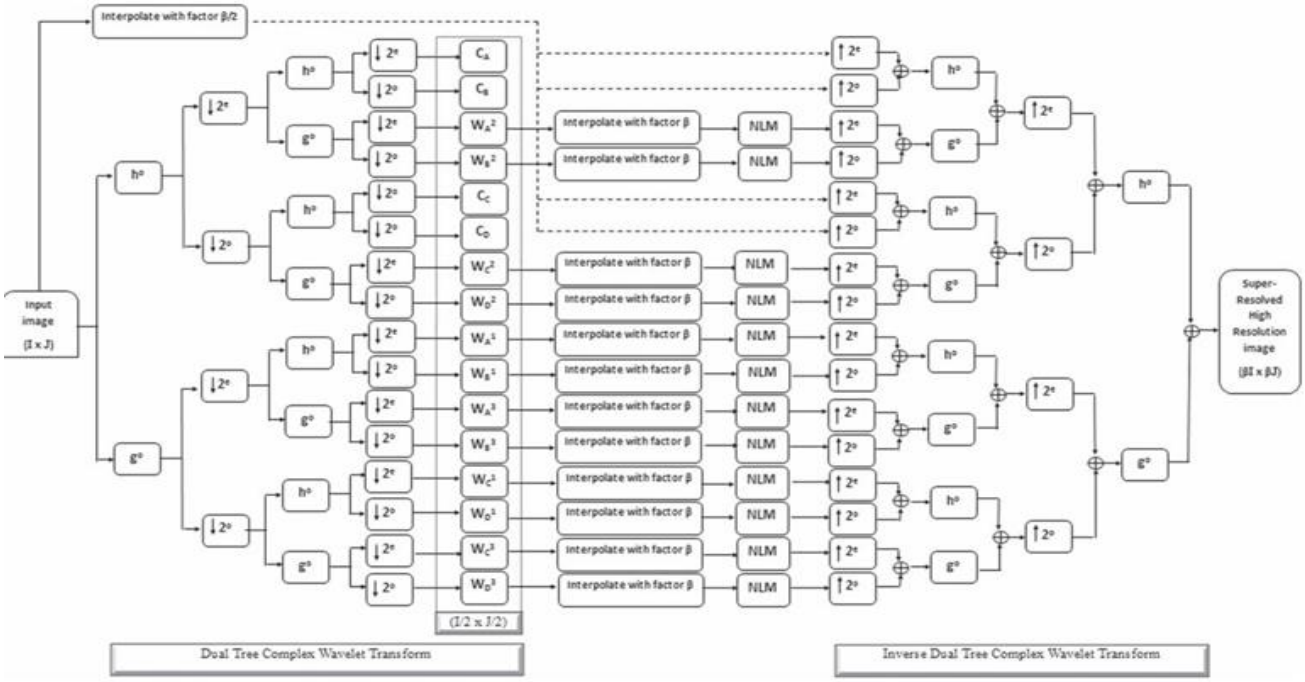

Fig.2 Block diagram of the DT-CWT RE Algorithm.

Lanczos Interpolation:-

Lanczos Interpolation function in 2D & low resolution input image is interpolated. Lanczos used to resizing the image. For Lanczos re-sampling and lanczos filtering, low pass filter used smoothen interpolated the value of the digital signal between sample.

Non local mean:-

Non local means is the algorithm in the image processing for image denoising.non local mean filtering takes a mean of every pixel in that image , weighted by how similar this are pixel are to the target pixel.12 sub-band are filter filtered & interpolated

Inverse DTCWT:

In Inverse DTCWT are combine the high frequency sub-band & low frequency Sub-band**.** Then resize 128*128 produced the high resolution Image

Resize & Resolution image:-

Then resize 128*128 produced the high resolution Image

3. Flowchart of Proposed Technique (DT-CWT NLM) :

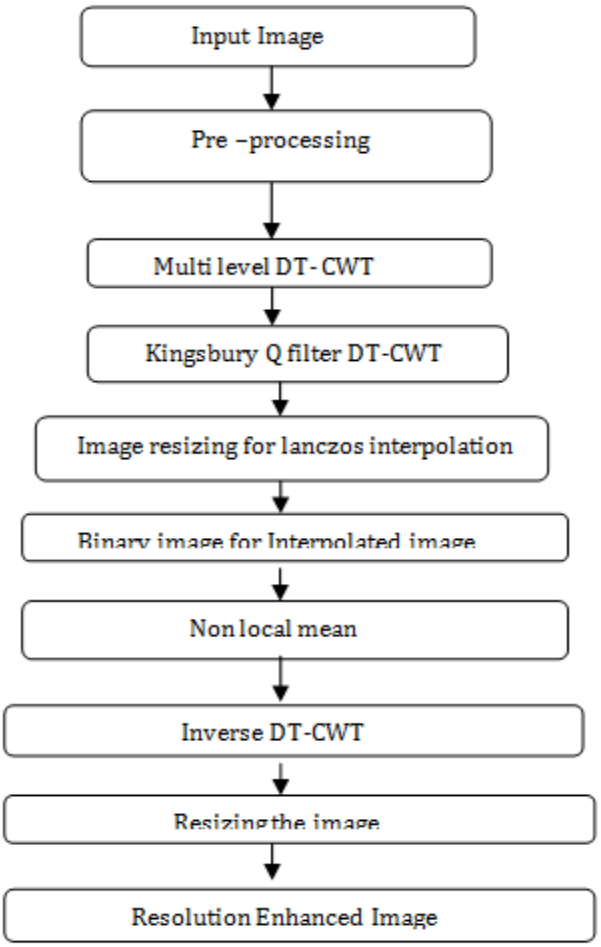

Figure 3: Flowchart of the proposed Method.

To estimate the performance of proposed technique algorithm different metrics such as, Mean Square Error (MSE), Peak Signal to Noise Ratio (PSNR) has been calculated.

4. Experiments and Result Analysis:

Result – (A) Image Resolution using DT-CWT NLM RE Technique :

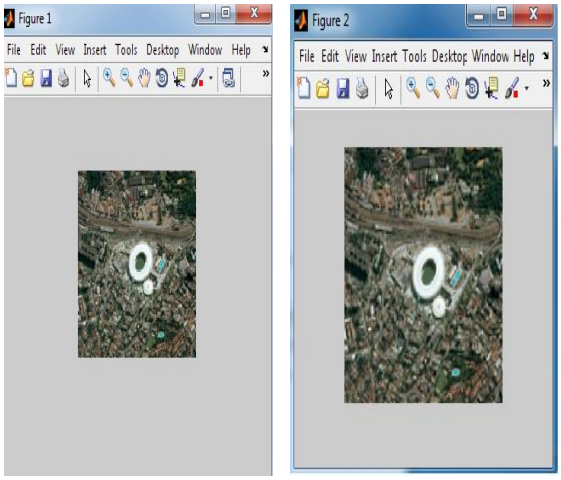

Fig4.Input Image1 Fig5.Output Image1

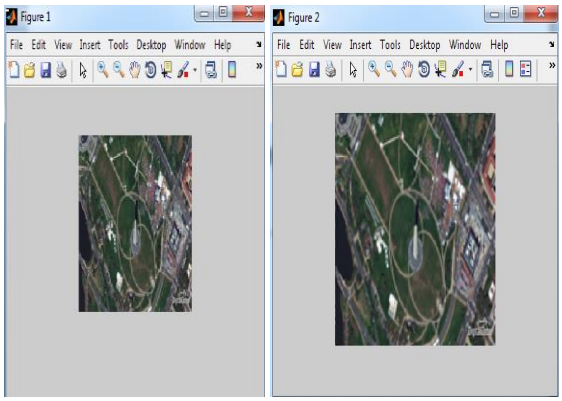

Fig6. Input Image2 Fig7.output Image2

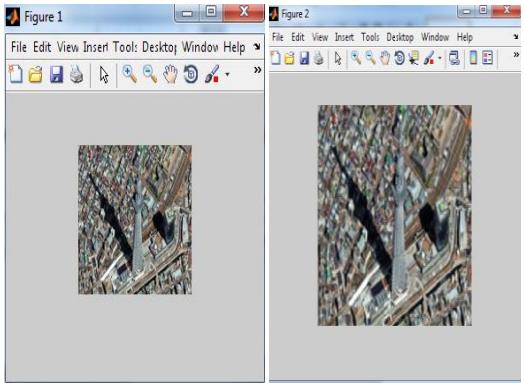

Fig8.Input Image 3 Fig9.output Image 3

Experimental Results:

Proposed DT-CWT-NLM-RE Technique(mathematical paramdeter)

Test Image	MSE	PSNR(dB)
Image 1	0.0182	17.40
Image 2	0.0176	17.55
Image 3	0.0197	17.06

Table I

- The Results obtained by proposed technique DT-CWT-NLM-RE are much better than another technique
- Table I. shows that in the proposed technique provide better result in the term of MSE,PSNR

5. CONCLUSIONS

An RE technique based on DT-CWT as well as an NLM filter has been proposed. Wavelet coefficients and the LR input image were interpolated using the Lanczos interpolator & The NLM filtering is used to overcome the artifact generated by DT-CWT & to enhance the performance of proposed technique in the term of MSE & PSNR & simulation results highlight the performance of proposed technique. In view of the above discussion the proposed system can be one of the best image resolution enhancement Technique.

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