Multi Scale Decomposition And Non-Local Means Based Satellite Image Resolution Enhancement

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Abstract:-
Multi scale decomposition based on dual-tree complex wavelet transform and non-local means is presented for SRE (satellite image resolution enhancement) of the satellite images. Resolution enhancement schemes (which are not based on wavelets) suffer from the drawback 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 is used 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 sub band and the low-resolution (LR) input image are interpolated using the bi-cubic interpolator. The high frequency sub bands are passed through an NLM filter to cater for the artifacts generated by DT-CWT. The filtered high-frequency sub bands and the LR input image are combined using inverse DT-CWT to obtain a resolution-enhanced image. The simulated results will show that technique used in this process provides better accuracy rather than prior methods.

Key words:
Satellite image Resolution Enhancement (SRE), Non-Local Means filter (NLM), Dual-Tree Complex Wavelet transform (DT-CWT), PSNR (Peak signal to noise ratio), MSE (Mean square error)

I.INTRODUCTION

Resolution is the capability of sensor to view the smallest object clearly with distinct boundaries. Resolution depends upon the size of pixel .If the size of the pixel is small then the resolution is more and object in the image will be observed clearly .If the size of pixel is small, then it occupies more space on the disk. There are four types of resolution while discussing satellite imagery in remote sensing. They are spatial, spectral, temporal and radiometric. Spatial resolution is defined as pixel size of image representing the size of the surface area being measured on the ground determined by the sensors in the instantaneous field view. Spectral resolution defined as the wavelength interval size (discrete segment of electromagnetic spectrum)and number of intervals that the sensor is measuring. Temporal resolution is amount of time that passes between imagery collection periods. Radiometric refers to effective bit depth of the sensor (number of gray scale levels) and it is typically expressed as 8-bit (0-255), 11bit (0-2047) etc. Many Interpolation techniques are used for image resolution enhancement. There are well known interpolation techniques namely nearest neighbor, bilinear interpolation and bi cubic interpolation. Bi cubic interpolation is more sophisticated than other two techniques.

SRE in the wavelet domain approach is a new research area. There are several SRE schemes such as DWT,DT-CWT. here we are proposing a SRE scheme based on DT-CWT and NLM.These technique has higher performance than conventional schemes.DT-CWT has greater advantages than DWT.DT-CWT is nearly shift invariant and directionally selective, but whereas DWT is shift variant and has poor directionality. Here we are proposing a technique based on DT-CWT based, bi cubic interpolation based, non-local means based approach. The results are compared with conventional schemes

II.PROPOSED TECHNIQUE

Resolution is important feature in satellite imaging, which makes the resolution enhancement of such images to be of vital importance. As it mentioned before, there are many applications of using satellite images, hence resolution enhancement of such images will increase the quality of the other applications. The main loss of an image super resolved by applying interpolation on its. Hence in order to increase the quality of super resolved image, preserving edges is essential. In this letter DT-CWT has been employed to preserve high frequency components of image.

In the proposed technique low resolution image taken as a input image then it is decomposed using DT-CWT into low

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frequency (LF) and high frequency sub-bands (HF). The HF sub-bands are interpolated with factor 2.The interpolated HF sub-bands are passed through the NLM to remove the noise components in the HF sub-bands and the low resolution image interpolated with factor2.This filtered interpolated HF sub-bands and low resolution image are combined using inverse DT-CWT. Thus the resultant image is an enhanced resolution image and is as shown in fig (1).

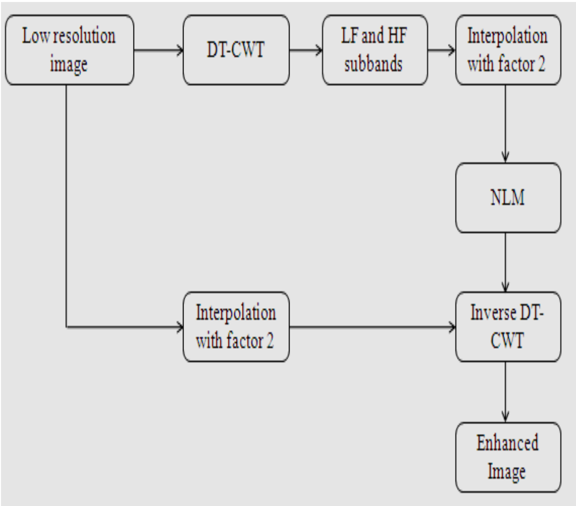

Fig (1).Block Diagram of proposed technique

A)DT-CWT:

The dual-tree complex wavelet transform (DT-CWT) is a relatively recent enhancement to the discrete wavelet transform (DWT), with important additional properties it is nearly shift invariant and directionally selective in two and higher dimensions. It achieves this with a redundancy factor of only 2*d* for *d*-dimensional signals, which is substantially lower than the un-decimated DWT.

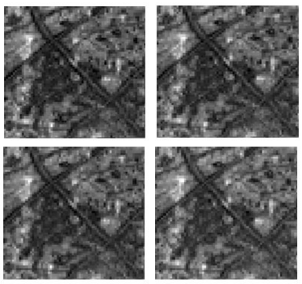

Fig2 (a).DTCWT Decomposition LF Sub-bands

The multidimensional (M-D) dual-tree CWT is non separable but is based on a computationally efficient, separable filter bank (FB). The theory behind the dual-tree transforms shows how complex wavelets with good properties can be designed, and illustrates a range of applications in signal and image processing. In the neighborhood of an edge, the real DWT produces both large and small wavelet coefficients .The decomposed components of DT-CWT are LF and HF. The LF components are shown in fig2 (a)and HF components are shown in fig2 (b).These decomposed HF sub-bands are bi cubic interpolated with factor 2 ,after that these are passed through NLM. The resultant image is resolution enhanced image.

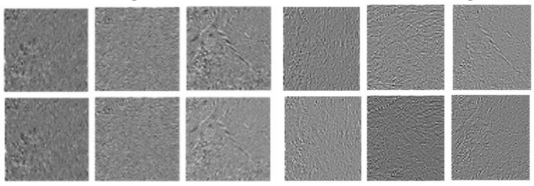

Fig2 (b). DT-CWT Decomposition HF Sub-bands

B) INTERPOLATION:

Interpolation is way through which images are enlarged. There are many different types of interpolation methods, each resulting in a different to the final picture. Thus, it is best if the quality, or visible distinction for each pixel, is retained throughout the enlargement process. Older methods of linear interpolation somewhat addressed this problem. By finding a mean pixel value between neighboring pixels, one was able to produce an effect of blurred edges and smoothed details.

Bilinear re-sampling uses the values from the four surrounding pixels and new pixel values are calculated by weighting the averages of the four closest pixels based on distance. The new pixel value is determined by calculating a weighted average of the four closest pixels (2x2 arrays) based on distance. However, bilinear interpolation seems to work better for image reduction rather than image enlargement.

CUBIC INTERPOLATION:

Cubic Convolution Interpolation determines the grey level value from the weighted average of the 16 closest pixels to the specified input coordinates, and assigns that value to the output coordinates. The image is slightly sharper than that produced by Bilinear Interpolation, and it does not have the disjointed appearance produced by Nearest Neighbor Interpolation. Expectation Maximization (EM) algorithm was used to train the Markov tree model. The algorithm essentially works by finding the set of parameters which would most likely result in the set of observed wavelet coefficients. In this particular implementation the algorithm takes as input the wavelet coefficients and produces the state transition probabilities, and the means and variances for each different state for each coefficient

C) NON- LOCAL MEANS APPROACH:

Non-local means filter is an algorithm in image processing for image de-noising. Unlike other local smoothing filters, non-local means filter averages all observed pixels to recover a single pixel. The weight of each pixel depends on the distance between its intensity grey level vector and that of the target pixel The NLM filter is based on the assumption that image content is likely to repeat itself within some neighborhood (in the image) and in neighboring frames. It computes de-noised pixel $x(p, q)$ by the weighted sum of the surrounding pixels of $Y(p, q)$ (within frame and in the neighboring frames).

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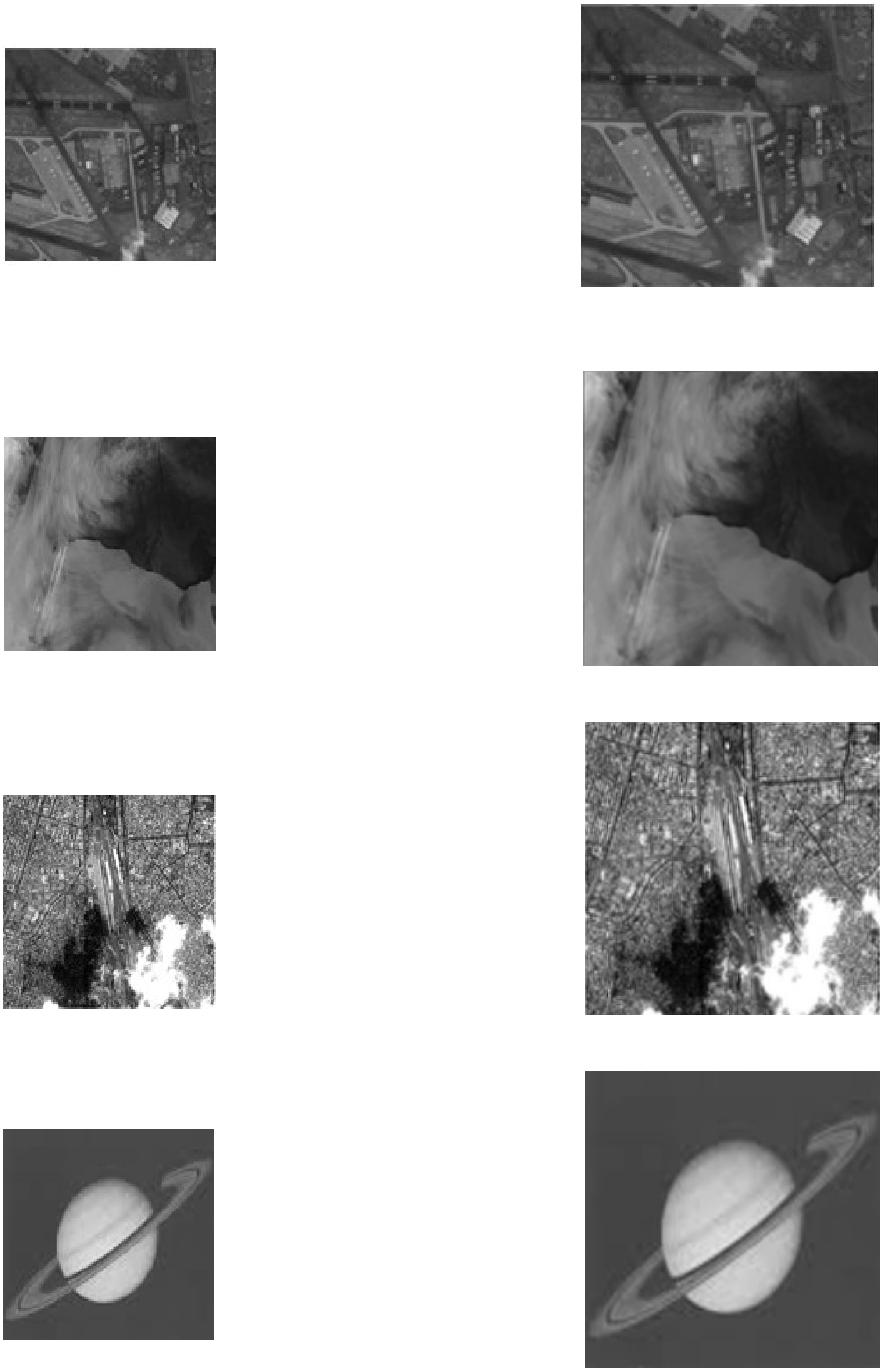
III.RESULTS AND DISCUSSION



(1)

(2)

(3)

(4)

(a) (b)

Fig3 (a).Input Image (b).Resolution Enhanced Image of Proposed Technique

From the above results it is evident that in the resultant image the resolution enhanced.The fig3 (a) shows the input image and the fig3 (b) is the resolution enhanced image of proposed technique, from that it is clear that there are no artifacts in the resultant image and it is having clear view than the existing technique. The result of image can be evaluated with two characteristics, distortion and sharpness. According to the distortion evaluation, adjusting errors are required, by computing the Mean Square Error (MSE). Mean square error has been the performance metric in lost performance and is obtained by using the below formula

MSE=sqrt ((∑∑ [P (i , j)-K(i , j)]^2/(MXN)))

Where P(i,j) is the enhanced image and K(i,j) is the input image .

Table1.MSE ANALYSIS

IMAGE	MSE VALUES	
	DWT	DT-CWT
IMAGE1	51.1587	0.013136
IMAGE2	60.0189	0.012299
IMAGE3	27.8561	0.010133
IMAGE4	25.4532	0.121589

The above table1 represents DT-CWT has less mean square error (MSE) compared to DWT.

Peak Signal to Noise Ratio (PSNR) adjusts the quality of the image which the higher the PSNR refers to the better quality is the image. Peak signal to noise ratio (PSNR) and root mean square error (RMSE) have been implemented in order to obtain quantitative results. PSNR, can be obtained by using the following formula

PSNR=10log 10[255X255/MSE]

Where MSE is the mean square error (255 is here as the images are represented by 8 bit ;) MSE is representing input image I1 and proposed enhanced image I2 which can be obtained by using formula of MSE.

TABLE2.PSNR ANALYSIS

IMAGE	PSNR VALUES	
	DWT	DT-CWT
IMAGE1	31.0416	66.9461
IMAGE2	30.3434	67.2322
IMAGE3	33.6816	68.0736
IMAGE4	32.6487	69.5432

The table2 represents the DT-CWT has higher PSNR value compared to DWT. So, DT-CWT has superior performance when compared to DWT.

IV.CONCLUSION

The proposed dual tree complex wavelet transforms better compatible to provide texture and edges of an image from different orientation. It was proved that a low resolution remote sensing image is enhanced to better visual perception by interpolating at high frequency sub bands and it reduces the problem of blocking and ringing artifacts because of its Shift invariant property. Here, Edge preservation filtering named as non local means filter also used for suppressing undesirable information from high frequency details while interpolation happened. This system will be enhanced to detect changes between two images taken at different time for surveying the earth surface. This module involves Difference image generation using Image fusion and neural network based segmentation technology.

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