*Review Article*

# Image Enhancement Using Dual Tree Complex Wavelet Transform

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**Abstract**: - Satellite Image Process normally arises during the process of image enhancement processing, which gives to improve the resolution of image and improving the edges of the images. This paper proposed a method for enhancement of images by Curvelet and Dual Tree Complex wavelet transform with filtering approach and interpolation techniques or methods. Firstly we improve the resolution of image by using the Curvelet Transform and then apply the image to dual tree Complex Wavelet transform for improving the edges of the images and finally pass the image with interpolation method ( bilinear and bicubic) to gives the clarity of image. The final result indicates the proposed method that has better performances to enhance the sharp edges of image.

**Keywords**: Curvelet Transform, Dual tree complex wavelet transform, Image enhancement and interpolation, Resolution Enhancement.

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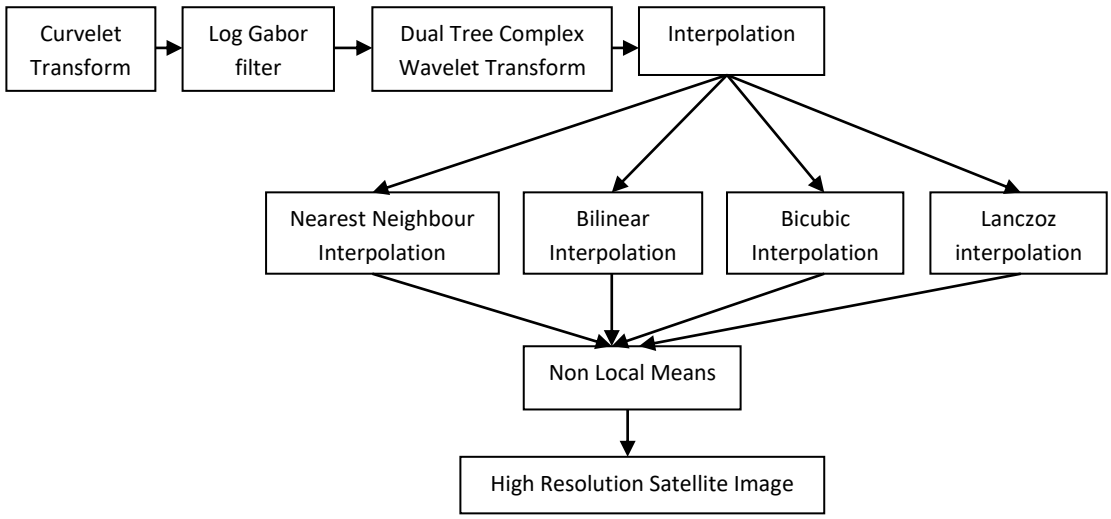
**Introduction**: Images enhancement is used extensively in numerous applications. Satellite image resolution enhancement technique base on interpolation of the high-frequency subband images obtained by dual-tree complex wavelet transform (DT-CWT) is proposed.

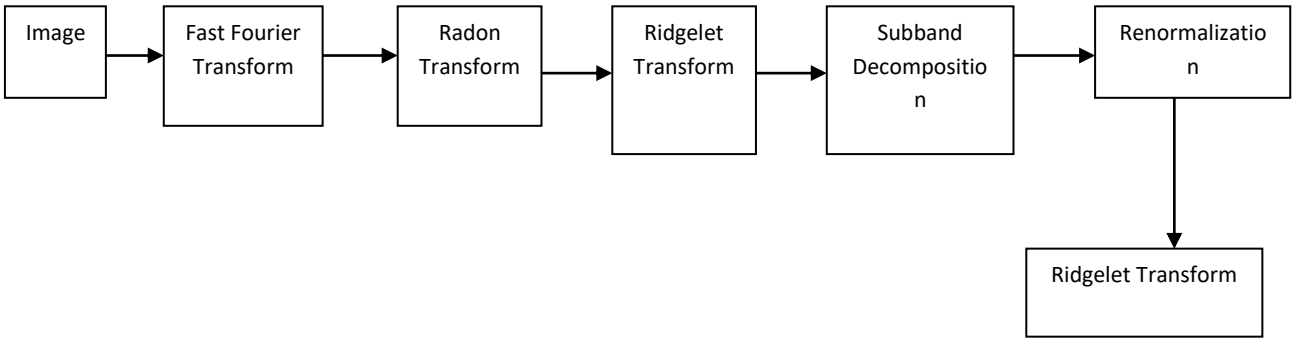
DT-CWT is used to decompose an input low-resolution satellite image into different subbands. Many interpolation techniques have been residential to increase the image resolution. There are four well-known interpolation techniques, namely, nearest neighbor interpolation, bilinear interpolation, bicubic interpolation and lanczos interpolation. Lanczos interpolation is more classy than the other three techniques; however, it produces perceptibly sharper images. Curvelets are a non-adaptive technique for multi-scale object representation. Curvelets are an appropriate basis for representing images (or other functions) which is smooth at a distance from singularities adjacent to smooth curves, where the curves have encircled curvature, i.e. where objects in the image have a lowest amount length scale. A curvelet transform differ from other directional wavelet transforms in that the degree of localization in bearing vary with scale. A dual-tree complex wavelet transform (DT-CWT) is introduced to assuage the drawbacks caused by the decimated DWT. It is shift invariant and has better-quality directional resolution when compared with that of the decimated DWT. Such facial appearance makes it apposite for image resolution enhancement. In this paper, a complex wavelet-domain image resolution enhancement algorithm based on the assessment of wavelet coefficients at HR scales is proposed. The opening estimate of the HR images constructed by applying a cycle-spinning methodology in the DT-CWT domain. It is then decomposed with the one-level DT-CWT to build a set of high-pass coefficients at the same spatial resolution of the LR image. The high-pass coefficients in concert with the LR image are used to renovate the HR image using inverse DT-CWT (IDT-CWT) [1].

The paper is organized as follows: Section 2 depict about the singular types interpolation techniques, illustration of curvelet transform is agreed in section 3 , section 4 describes about the illustration of dual tree complex wavelet transform, projected methodology is described in section 5 and finally in section 6 results and conclusion are given.

Fig indicates that firstly we take a satellite image and it pass through the curvelet transform to improve the resolution of image after curvelet transform the image is passed through the log gabor filter the function of log gabor filter is to enhance the image with providing the little bit clarity and also remove the blurred of the images after log Gabor filter the image is passed through the dual tree complex wavelet transform the function of dual tree complex wavelet transform is to improve the image and also improve the edges of the images so that both noises and clarity of the image is occur. And after those interpolation techniques is used. In this there are four interpolation techniques are used i.e. nearest interpolation techniques, bilinear interpolation, bicubic interpolation and lanczoz interpolation. The output of the interpolation is passed through the non local means basically a non local means a filter which is used to give the clarity of the images and also improve the contrast of images and finally we get the high resolution satellite image




**CURVELET TRANSFORM**




The curvelet transform is a multiscale dimensional technique which is used to the blurred of the images. And also increase the resolution of the images.The various steps followed in Curvelet transform are

* Subband Decomposition
* Smooth Partition
* Renormalization
* Ridgelet Analysis

In the Subabnd decomposition firstly the image is divided into the bands so that each and every point of the images should easily be decompose so that its easily remove blurred.

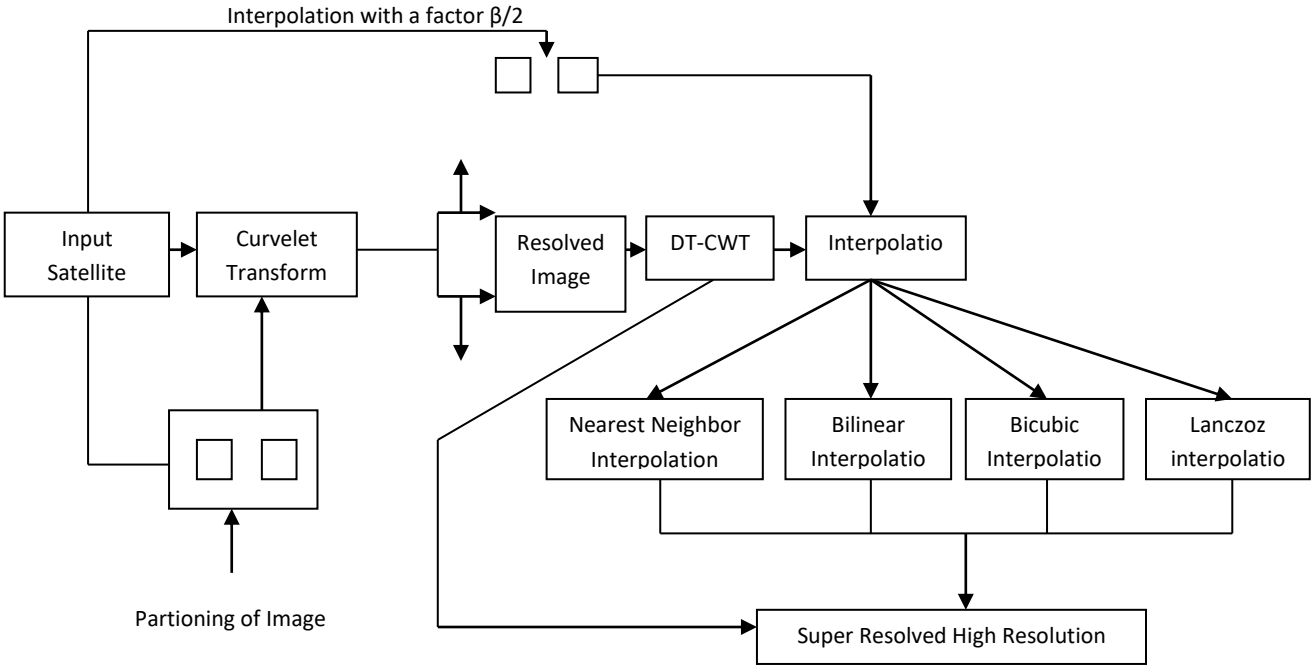
When subbabnd decomposition process occurs then the function of smooth partioining is to give smoothness of the images which clear the image in internally. Log gabor filter is also used to remove the noises in the image.

Renormalization process is used to give the clearoty of the image with internally and externally within each row and column of the images. When subband images of the process occur renormalization then its improve the images through row and column.

Last process is Ridgelet Analysis In this analysis the images clearity occur by the portioning of the image.

Fig shows the proposed methodology of the resolution enhancement. In this proposed methodology firstly we take an image of input satellite and then the satellite image is passed through the Curvelet transform and for removing the noises we interpolate an image with interpolation with a factor β/2. In Curvelet transform the portioning of the image process is occur in which to improve the clarity of the image within this we apply Gabor filter and the output of Gabor filter is the resolved image and then to improve the edges of the images we apply the image through Dual Tree Complex Wavelet transform and after that interpolation techniques is applied to improve the contrast and visibility of the image. There are four types of interpolation techniques are used i.e. nearest interpolation techniques, bilinear interpolation, bicubic interpolation and lanczoz interpolation. And the output of the interpolation techniques and within this again applies the Dual tree complex wavelet transform and then finally we get the super resolved high resolution image.

**Block Diagram of Proposed Resolution Enhancement**




**Block Diagram of 1 level DTCW**

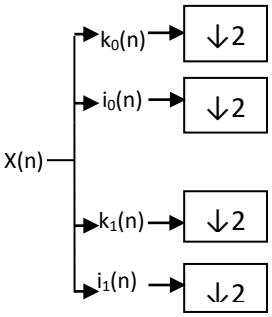
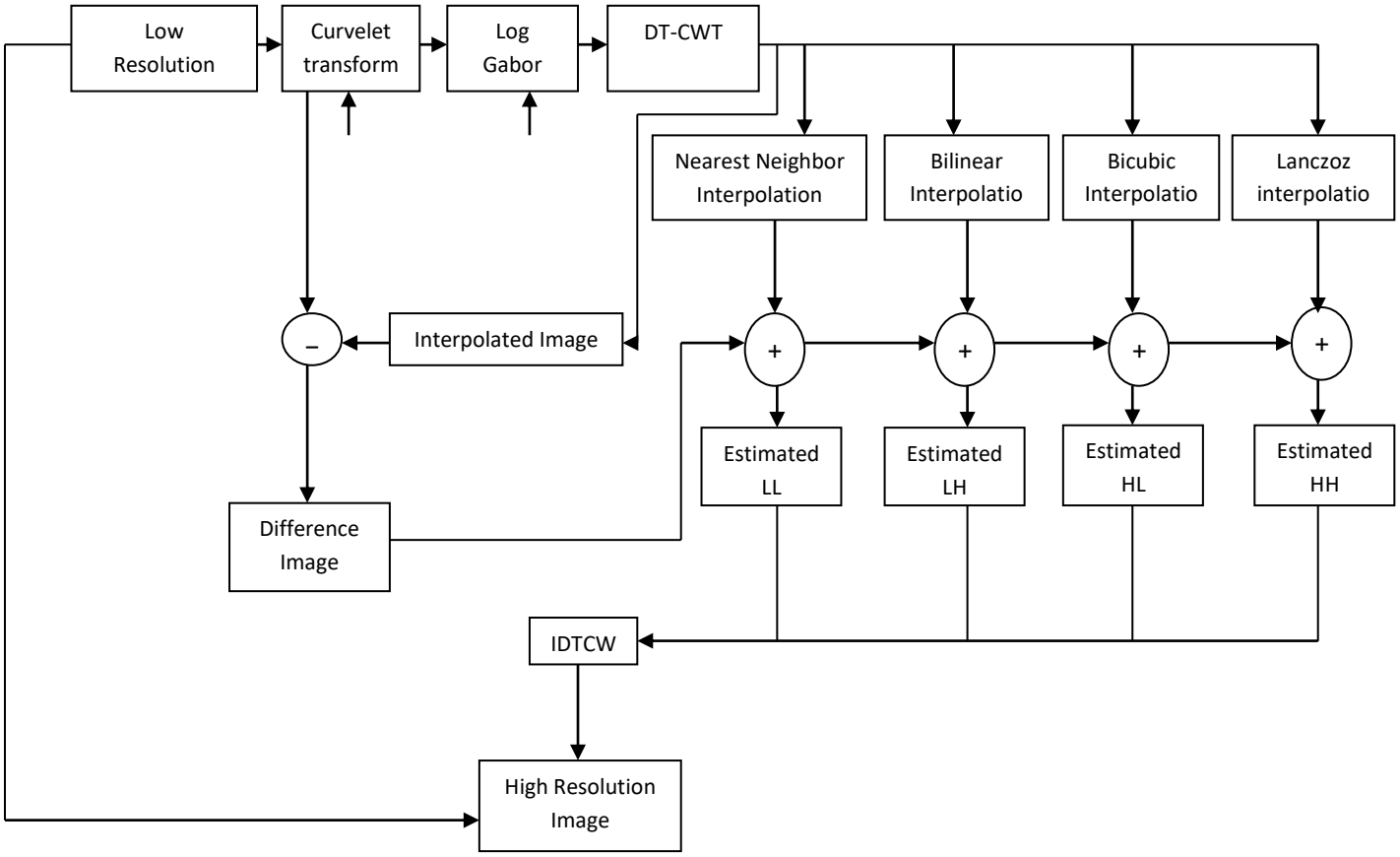



Fig shows the block diagram of 1 level DTCWT where x(n) is the input and this input is applied through the gain and impulse response to decrease the noise of the image and after we decrement by factor 2 so that the output of the image resolution is better same operation is to be performed so that finally we get the resolved image.

Fig shows the proposed methodology of the given satellite image enhancement process using Curvelet and DTCWT . In this proposed method firstly we take a low resolution satellite image and this image is passed through the Curvelet transform for image denoising and to improving the resolution of the image. In Curvelet transform the portioning and sub band of the images occur so that proper resolution of the image process occurs. When the Curvelet Process occurs in between the image is passed through the difference Image which removes the blurred of the image. The output of the curvelet transform is passed through the Log Gabor Filter. The function of Log Gabor is to provide the clarity and also improve the resolution of the image. The output of the Log Gabor Filter is applied to the Dual tree Complex wavelet transform, and the output of the Dual Tree Complex Wavelet transform is passed through the different interpolation method. The four interpolation method is used and within that when the interpolation is applied at that instant different estimated filter techniques are also applied E.g.: when we apply Nearest Interpolation method then the image is to be estimated by LL which means Low- Low, when we apply Bilinear interpolation then the image is to be estimated by LH which means Low-High, when we apply Bicubic interpolation then the image is to be estimated by HL which means High- Low and when we apply Bicubic interpolation then the image is to be estimated by HH which means High- High. The output of the interpolation is applied to the inverse Dual tree complex wavelet transform. And after applying all the

processes finally we got the high resolution satellite image.

**Proposed Methodology:-**




**Three-Stage analysis Subband Coding**

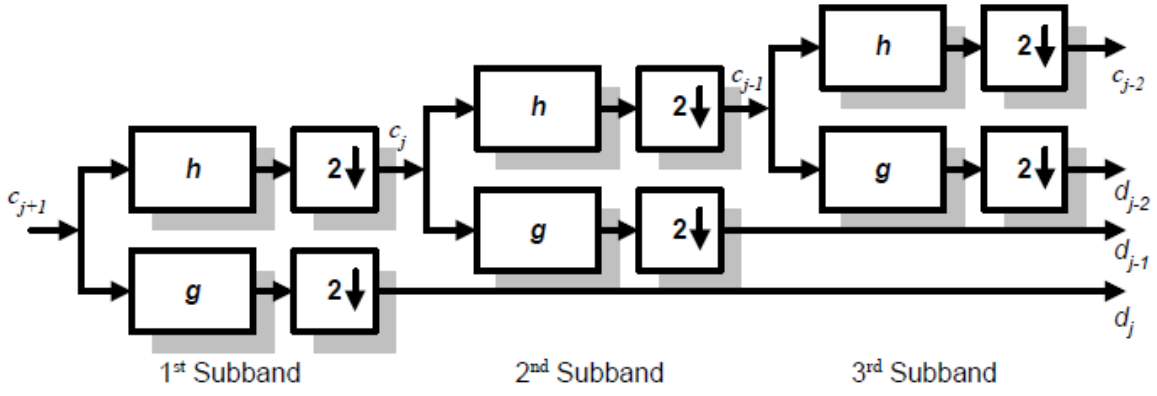



Fig shows the three stage analysis of sub band coding in the first sub band the input image is applied to the log Gabor filter and within this the impulse response is applied which decrement the image by the interpolated factor by β/2 the output of the first subband is again passed through the same process which also decrement by the interpolated factor β/2. The same process is done until we got the high resolute image.
The Curvelet transform and dual tree complex wavelet transform achieves excellent result at high noise intensity to other transform techniques.
The following measuring parameter is used:

**Mean Square Error (MSE):** The MSE (Mean Squared Error) represents the cumulative squared error between the reconstructed and the original image, whereas PSNR represents a measure of the peak error. The lower the value of MSE, the lower the error[3]. To compute PSNR the mean-squared error is first calculated using the following equation.

$$MSE = \frac{\sum_{M,N} [I_1(m,n) - I_2(m,n)]^2}{M * N}$$

Where M and N are the number of rows and columns in the input image.

**Peak Signal To Noise Ratio (PSNR):** The PSNR calculates the peak signal-to-noise ratio, in decibels, between two images. This ratio is used as a quality measurement between the original and a reconstructed image. The higher the PSNR, the better the quality of the reconstructed image.

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

where R is the maximum fluctuation in input image. For a 8-bit image value of R is 255.The Mean Square Error (MSE) and the Peak Signal to Noise Ratio (PSNR) are the two error metrics used to compare image reconstruction quality.

**Proposed Technique:-**

In the proposed techniques of combination of curvelet and dual tree wavelet transform with Non local means filtering techniques improves the pixels of the image through both row and columns' and also improve the resolution of the images. The combination of the interpolation techniques helps to improve the clearity of the image so that image should be clear. The four types of the interpolation techniques is used, these all interpolation techniques basically work on low low, low high, high low and high high.

These improve the quality index of the image by using this filtering approach techniques. The interpolated image looks clear in every format. In the proposed technique the image will be clear in every format such that the resolution and the clarity of the images should be done. By calculating the different parameter it will show that the image clarity is done.

**Result and Discussion:**

To give the effectiveness of the image the proposed resolution images should be used to give the clearity of the images. By comparing the interpolation techniques with different interpolation method the subband and portioning of the images should be clear by using the Low Low, low High, High Low, High High process techniques which will be used in the interpolation techniques. The parameter gives the clear indication of the images that it will improve the quality index of the images and the resolution of the images. It should be clear that the by using the proposed techniques the results should be much better than the other techniques.nad within that proposed techniques we use Log gabor filter which will improve the resolution of the images internally and the resolution of thre images will be very clear.

| INTERPOLATION TECHNIQUES | PSNR | MSE | ENTROPY | Quality Index |
|---|---|---|---|---|
| 1. NEAREST NEIGHBOUR | 27.7313 | 0.0029 | 7.5600 | 0.9918 |
| 2. BILINEAR | 28.3612 | 0.0035 | 7.5538 | 0.9927 |
| 3. BICUBIC | 29.3995 | 0.0048 | 7.5432 | 0.9942 |
| 4. LANCZOS | 30.0289 | 0.0087 | 7.5389 | 0.9959 |

(a) (b)

(c) (d)

(e) (f)

(g) (h)

Fig. (a) Input Image (b) Curvelet Transform Output
(c) DTCWT Transform (d) Gabor Filter Output
(e) Nearest Neighbour (f) Bilinear Interpolation
(g) Bicubic Interpolation (h) Lanczoz interpolation

## Conclusion:

The proposed techniques which is based on the different transform techniques and to give the high resolution different types of interpolation techniques is to be used. By using the different interpolation techniques we easily study the images of the row and columns and within that interpolated we can resolute the images in different format. To give the enhance and performance of the given techniques following parameter is to be calculated i.e: P.S.N.R, Entropy, M.S.E and Quality Index.

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**Conflict of interest: Nil**
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