Noise, Edge and Resolution Enhancement of Satellite Images

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Abstract— Satellite images are used in many applications like meteorology, agriculture, geology, biodiversity conservation, education etc.Enhancement of satellite image is very important process. In this paper in the proposed method, we discuss the technique of satellite image enhancement by removal of noise and enhancing the edge, resolution.The edges of an image can be improved by using curvelet transform, noise is removed by using a suitable noise removal filter and resolution is increased by using interpolation technique. This is the process in which all the three (Noise,edge,resolution) parameters of a satellite image are improved. We also discuss the other combination techniques which uses transform techniques and interpolation methods for enhancement of images.

Index Terms— DWT, SWT, CWT, Curvelet, Interpolation, Noise.

1 INTRODUCTION

The aim of image enhancement is to improve the interpretability or perception of information in images for human viewers, or to provide `better' input for other automated image processing techniques. Image enhancement process is needed in every image process applications. The satellite images are needed to be enhanced both in terms of edges and resolution so that the enhanced image looks better in terms of quality.

Image enhancement is done using a combination of transform technique and interpolation methods. Edges in an image can be improved by using transform techniques. Wavelet transform techniques are used effectively for edge improvement, but as it is not proper to the image with directional element, we use Curvelet transform for edge improvement. Image resolution is also an important parameter for image enhancement, this can be done by using the interpolation. Interpolation is a method of increasing the number of pixels in an image. The various interpolation techniques used are Nearest Neighbour, Bilinear, Bicubic and curvature.

The paper is organized as follows: section2 describes about the image enhancement using discrete wavelet transform. Section 3 describes the method of image enhancement using wavelet and noise removal filter, Section 4 describes image enhancement using stationary wavelet, section 5 describes about complex wavelet transform and finally section 6 describes proposed method using a combination of curvelet transform and interpolation for image enhancement

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2. Image enhancement by using combination of Discrete Wavelet Transform(DWT) and Interpolation Technique

Image Resolution enhancement using DWT [1] is a very popular technique. Image resolution is enhanced by using interpolation technique. Bicubic interpolation is used in this method to increase the number of pixels in the image. The loss occurred due to smoothing caused by interpolation of high frequency components are avoided by using the discrete wavelet transform by which the edges are enhanced. Wavelet plays a very important role in many image processing applications. The 2D wavelet decomposition of image results in four decomposed sub band images referred as low-low (LL), low-high(LH),high low(HL) and High- high(HH). Fig.1 [7] shows the block diagram of DWT filter bank.

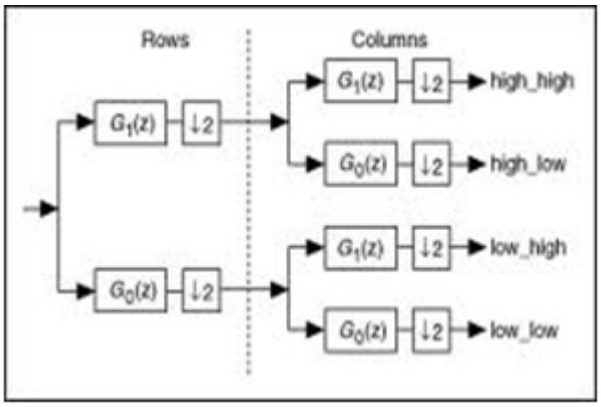

Fig.1 Block Diagram of DWT Filter bank

From the fig.2 the high frequency subband images and the input low resolution images have been interpolated to gen-

erate a new resolution enhanced image. Although this method gives a resolution enhanced image, the wavelet based approach need many wavelet coefficients to accounts for edges. (i.e) singularities along lines or curves and also it lacks from directional selectivity and translational invariance. So this is improved by using the dual tree complex wavelet transform and stationary wavelet transform. There are also other directional wavelets like steerable wavelets, Gabor wavelets, wedgelets, Beamlets, bandlets, contourlets, shearlets, wave atoms, platelets etc.

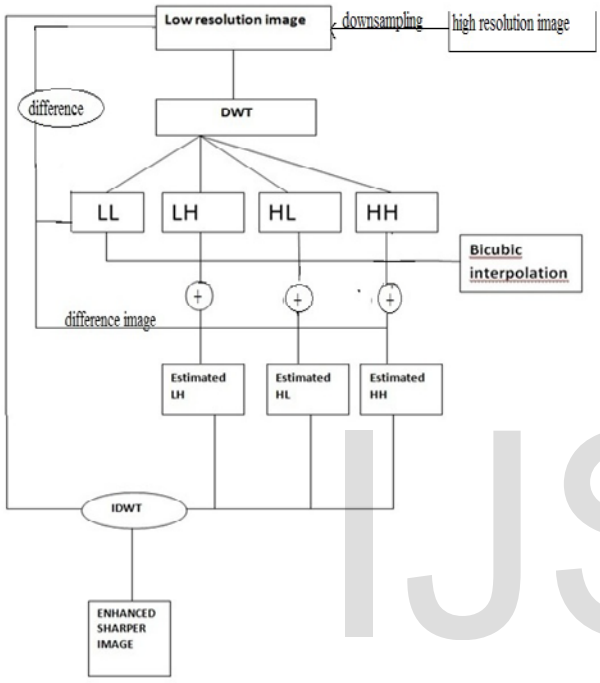

Fig.2 DWT Based method of Image enhancement

3. Image Enhancement using Combination of Wavelet and Interpolation with addition of Noise filter

In this method of Image enhancement the image is enhanced by using the unsharp filter which makes the image sharper and clearer. Unsharp filter is used at the input image directly and we get the filtered output. Noise has been removed from the input image and the filtered image is further down sampled to get the low resolution image. This low resolution image is further decomposed using DWT and Bicubic interpolation is used to increase the resolution of the image.The diagrammatic representation is shown in the figure(3).

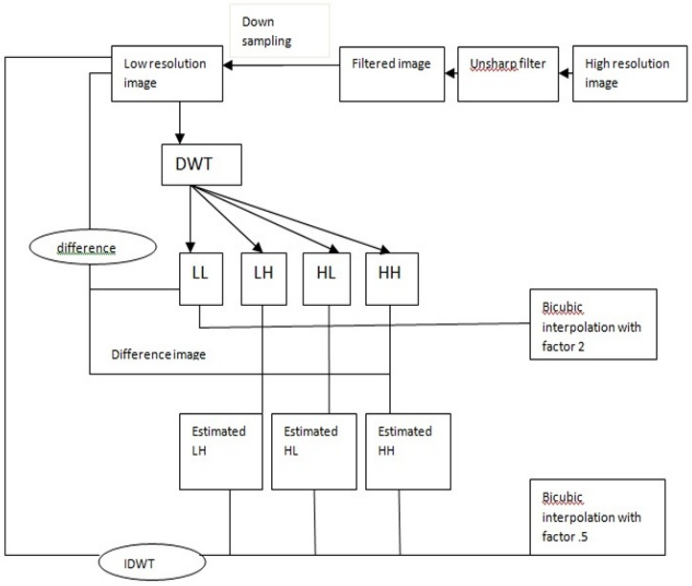

Fig:3 Image enhancement by using DWT and Noise removal filter.

4. Image Enhancement using Stationary Wavelet Transform

The stationary wavelet transform is a wavelet transform algorithm designed to overcome the lack of translational invariance [6] of discrete wavelet transform. It is similar to DWT but it does not use downsampling hence the subbands will have the same size as input image [2]. Downsampling in each of the sub-bands of DWT cause information loss that's the reason why SWT is employed. Image produced at the output will be of sharper high resolution image.

5. Image Enhancement using Complex Wavelet Transform (CWT)

Complex wavelet transform based approach of image enhancement is one of the recent approaches used in image processing and also an improvement technique of discrete wavelet transform. The lack of poor directionality of DWT is improved in CWT.Resolution enhancement is achieved by using directional selectivity provided by CWT. The high frequency subband in 6 different directions contributes to the sharpness of high frequency details such as edges. Dual tree complex wavelet transform (DT-CWT) [3] is used to decompose an image into different subbands. One level CWT of an image produces 2 complex valued low frequency images and 6 complex valued high frequency images. The high frequency subband images are the results of directional selective filters.They show peak magnitude responses in the presence of image features oriented at $+75^0$,$+45^0$,$+15^0$,-15^0,-45^0,-75^0. The loss in the edges of the image are improved by using CWT.The diagram below shows

the image enhancement method using DT-CWT. Interpolation is applied to the high frequency subband images.

The advantages of using DT-CWT are high directional selectivity when compared to DWT. It also has limited redundancy, shift invariant.
It is difficult to design complex wavelets with perfect reconstruction properties and good filter characteristics [4]. DT-CWT added perfect reconstruction to other attractive properties of complex wavelet including shift invariance, six directional selectivities, limited redundancy and efficient computation.

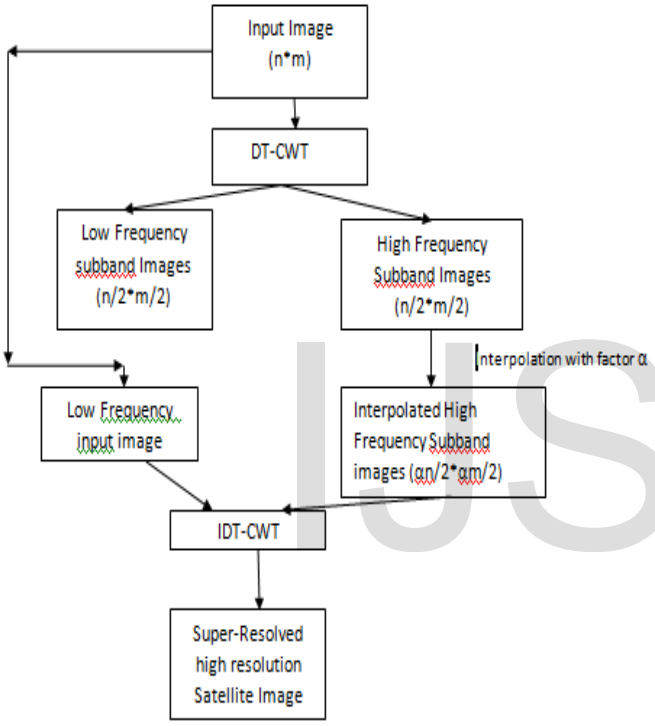

Fig.4 DT-CWT based method of Image Enhancement

6. Proposed Methodology

In the proposed method of image enhancement, the input image which contains noise is removed by using a noise removal filter like Gabor filter or any other filter of same kind. The noise removed image is given as an input to the curvelet transform. The purpose of using curvelet transform is to enhance the edges present in the image. The edge plays an important role in identification of image. The wavelet based approach of edge enhancement is not proper to the image with directional element whereas the curvelet based approach is high sensitive to directional image and edge, and the advantage of curvelet is that it handles the curve discontinuities very well. The various steps used in curvelet transform are represented in the figure (6). The decomposed image is interpolated using Cubic interpolation .Interpolation is a technique of increasing the number of pixels of the given image. Finally inverse curvelet transform in applied to the coefficients by which we get the image enhanced in terms of edge, resolution and by removal of noise. The quality of the image can be evaluated by using the parameters like PSNR, RMSE and Entropy.

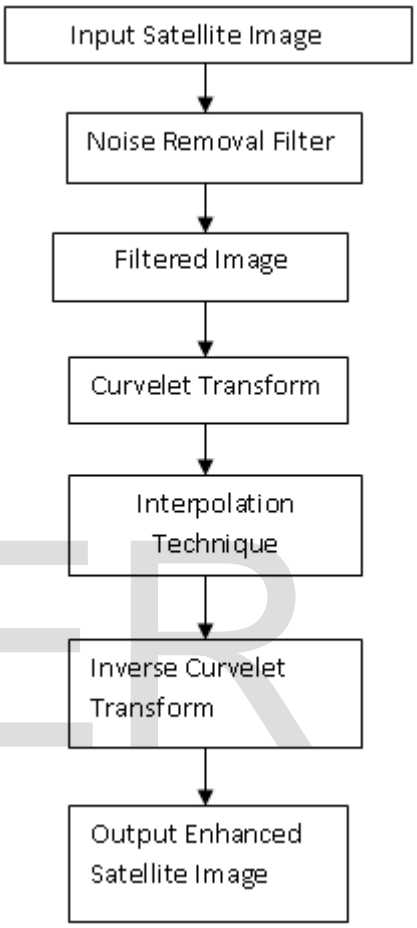

Fig 5: Block Diagram of Proposed method of Satellite Image Enhancement

7. Conclusion

This paper gives a brief review of the methods used for satellite image enhancement using the combination of transform technique and interpolation method. The proposed technique enhances the image by removal of noise, increase in the resolution and edges of the image.The quantitative parameters like PSNR,RMSE and Entropy can be used to evaluate the quality of the image.

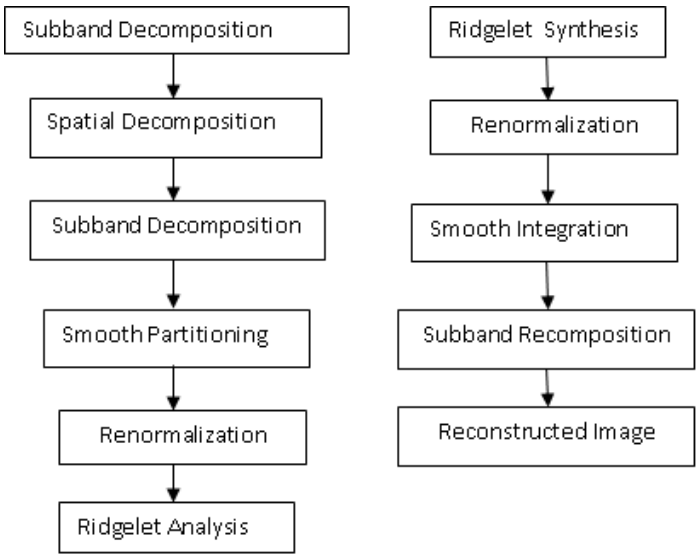

Fig 6: Block Diagram of the process of Curvelet Transform

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