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Resolution Enhancement of Image Captured by Satellite Using DWT

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Abstract

Satellite images are used in different fields of research resolution is the major issue of such images. So it is essential to have high resolution satellite images. Satellite images are affected by various factors such as absorption, scattering etc in the space, Resolution of these images is very low. To have better perception of these images it is necessary to have the image with clear and well defined edges, which provides better visible line of separation etc. Resolution enhancement of these images has always a major issue to extract more information from them. Wavelet domain based methods have proved themselves as most efficient technique for the required purpose. Interpolation in image processing is a well-known method to increase the resolution of a digital image. Many interpolation techniques have been developed to increase the image resolution. The three different types of interpolation techniques used are nearest neighbor, bilinear and Bicubic interpolation. Several image enhancement techniques have been proposed. In this work a new satellite image resolution enhancement technique based on the interpolation of the high-frequency sub bands obtained by discrete wavelet transform (DWT) and the input image. The proposed resolution enhancement technique uses DWT to decompose the input image into different sub bands. Then, the high-frequency sub band images and the input low-resolution image have been interpolated, followed by combining all these images to generate a new resolution-enhanced image by using inverse DWT. In order to achieve a sharper image, an intermediate stage for estimating the high-frequency sub bands has been proposed. The proposed technique has been tested on satellite benchmark images. The quantitative (peak signal-to-noise ratio and root mean square error) and visual results show the superiority of the proposed technique over the conventional and state-of-art image resolution enhancement techniques.

Keywords: Resolution Enhancement, Image, Satellite, DWT

1. Introduction

1.1 Need of Image Resolution Enhancement

Resolution of an image plays very important role in many image and video-processing applications, such as video resolution enhancement, feature extraction, and satellite image resolution enhancement^[1]. Satellite image has low frequency so it appears as blurred image. To improve the frequency of those images, image Resolution techniques Needed. Enhancing the resolution of an image includes improving the number of pixels available to represent the details of image.

1.2 Challenges in Image Enhancement

Image captured by satellite has low frequency components so these images are blurred image improving the quality of such image or enhancing the resolution is quite difficult. Edges of images are with poor quality so it goes to tough to improve the quality of such images. In this paper new satellite image resolution enhancement technique based on the interpolation of the high-frequency sub bands obtained by discrete wavelet transform (DWT) and the input image, is presented. The proposed resolution enhancement technique uses DWT to decompose the input image into different sub bands. Then, the high-frequency sub band images and the input low-resolution image have been interpolated, followed by combining all these images to generate a new resolution-enhanced image by using inverse DWT. In order to achieve a sharper image, an intermediate stage for estimating the high-frequency sub bands has been proposed. The proposed technique has been tested on satellite benchmark images. The quantitative (peak signal-to-noise ratio and root mean square error) and visual results show the superiority of the proposed technique over the conventional and state-of-art image resolution enhancement techniques.

2 Image Enhancement Techniques

The principal objective of image enhancement is to modify attributes of an image to make it more suitable for a given task and a specific observer. During this process, one or more attributes of the image are modified. The enhancement methods can broadly be divided in to the

following two categories

1. Spatial Domain Methods
2. Frequency Domain Methods

In spatial domain techniques we directly deal with the image pixels. The pixel values are manipulated to achieve desired enhancement. In frequency domain methods, the image is first transferred in to frequency domain. It means that, the Fourier Transform of the image is computed first. All the enhancement operations are performed on the Fourier transform of the image and then the Inverse Fourier transform is performed to get the resultant image [13]. Interpolation process is nothing but the image synthesis operation. This process is performed row by row and then column by column. The different type of interpolation methods are explained as below [1, 10].

2.1 Bilinear Interpolation

The bilinear interpolation has a large popularity due to its simplicity of implementation. Bilinear uses points to perform bilinear interpolation. This is done by interpolating between the four pixels nearest to the point that best represents that pixel [11].

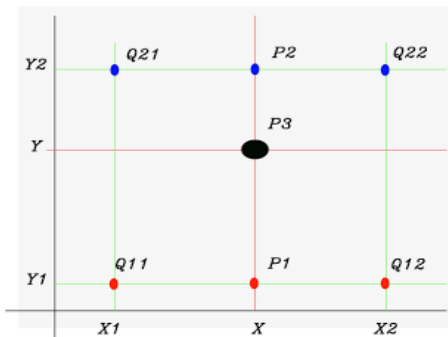


Fig 2.1: Bilinear Interpolation Method

Figure 2.1 shows the bilinear interpolation scheme, we have to calculate the value of P3. The pixel value of P3 is weighted average of nearest four pixels. Hence the pixel value of P3 is weighted average of the pixel value Q21, Q22, Q11 and Q12. To implement the same first Q21 and Q22 linearly interpolated and P3 is calculated. Then Q11 and Q12 interpolated and the value of P1 calculated. by using the value P1 and P2, P3 pixel value is determined. As the two linear interpolation methods are used so it called as bilinear interpolation method. Followings are the equations used to calculate interpolated pixel.

The equation 2.1 calculate the pixel value P1 by taking the value of Q11 and Q12

$$F(P1) = \frac{X2-X}{X2-X1} \times F(Q11) + \frac{X-X1}{X2-X1} \times F(Q12) \dots\dots\dots(2.1)$$

The equation 2.2 calculate the value of pixel P2 considering the value of Q21 and Q22

$$F(P2) = \frac{X2-X}{X2-X1} \times F(Q21) + \frac{X-X1}{X2-X1} \times F(Q22) \dots\dots\dots(2.2)$$

The equation 2.3 calculate the value of pixel P3 considering the value of P1 and P2.

$$F(P3) = \frac{Y2-Y}{Y2-Y1} \times F(P2) + \frac{Y-Y1}{Y2-Y1} \times F \dots\dots\dots(2.3)$$

2.2 Nearest Neighbor Interpolation

Nearest neighbor interpolation is the simplest interpolation scheme. It is the most basic interpolation technique and

requires less processing time among all the interpolation techniques. In this technique the interpolated pixel is replaced by the nearest pixel. Nearest neighbor interpolation is a simple method of linear interpolation. It is easy to implement. It gives good result when the image has high resolution pixels. In this some information at the edges is lost. The interpolation kernel for nearest neighbor interpolation is,

$$u(x) = \begin{cases} 0 & |x| > 0.5 \\ 1 & |x| < 0.5 \end{cases} \dots\dots\dots(2.4)$$

Where x = distance between interpolated point and grid point. Enlargement requires two steps:- First is creation of new pixel locations and second is assignment of pixel values to those locations. This can be done by treating image as a matrix and creating new rows and columns by padding it with matrix having double the size of original image matrix and having only zero value so that every alternate row s or columns of resultant matrix contains zero as its pixel value. Next step is to assign the pixel value of the near most neighbor to the newly generated pixel. That is why this method of grey level assignment is called Nearest Neighbor. The flowchart is shown below

2.3.2 Disadvantages of nearest neighbor interpolation

- 1) Blur in output image increases.
- 2) This technique may produce distortion in edges.
- 3) Nearest neighbor method shows the mosaic phenomenon

2.3 Bicubic Interpolation

Another one method which is significantly effective in signal is the Bicubic interpolation Cubic convolution is a Technique used to determine the gray levels in an image. This is determined by the weighted average of the 16 closest pixels to the input coordinates. Then that value is assigned to the output coordinates.

2.3.1 Flow Chart for Bicubic interpolation

This method is slightly better than bilinear interpolation, and it does not have the disjointed appearance of nearest neighbor interpolation. This resampling calculates a distance weighted average of a block of sixteen pixels from the original image which surround the new output pixel location [10, 11]. Image

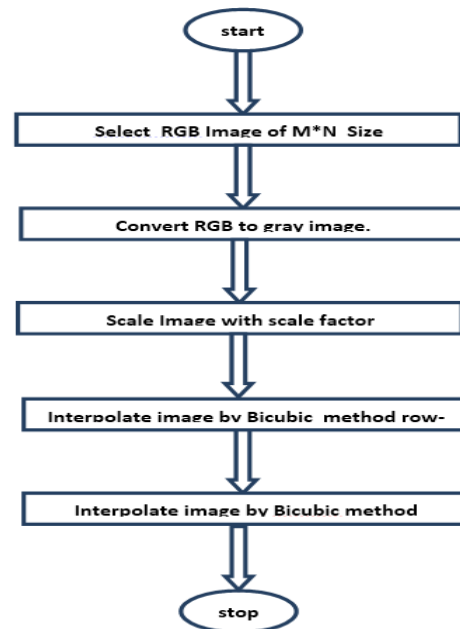


Fig 2.2: Flow Chart for Bicubic Interpolation

Figure 2.2 shows the flow chart details of the Bicubic interpolation method.

3 Proposed Method

Low resolution image of $m \times n$ size is accepted as input to the proposed method DWT transform dissiminate the image into four sub-bands the high frequency sub-bands are interpolated by bicubic interpolation method to get the estimated sub-bands this interpolation is done with the help of difference image. The difference image is obtained with difference of interpolated LL band and low resolution image. The LL bands of image contain the image information and the high

frequency components or high frequency band contain the texture of the image. The estimated bands are the nothing but horizontal components, vertical components and diagonal components of the image. These components are enhanced by the interpolation method. Bicubic interpolation gives here the sharpness in the edged. It helps to improve the PSNR of the image. Bicubic interpolation improves RMSE value of the output image. Inverse Discrete Wavelet Transform of the estimated sub-bands gives the high resolution image. IDWT takes the estimated sub-bands output and low resolution image as input to get resolution enhanced image as output.

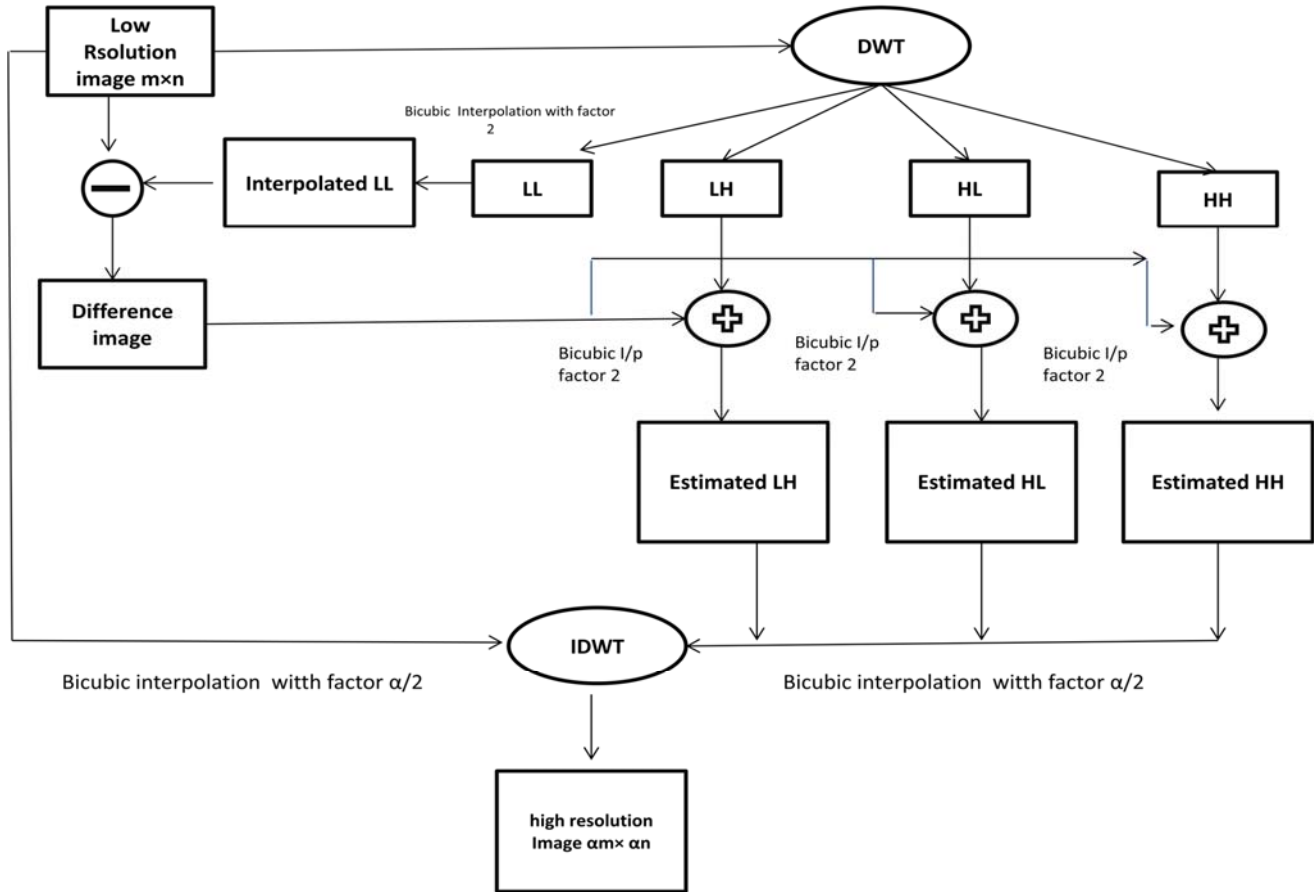


Fig 3.1: Block Diagram of Proposed Method

3. DWT Based Resolution Enhanceme-nt

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 The technique decomposes the input image into the four frequency sub- bands by using DWT and estimates the singular value matrix of the low-low sub band image, and then it reconstructs the enhanced image by applying inverse DWT [1-10]. DWT has been employed in order to preserve the high-frequency components of the image. DWT separates the image into different sub band images, namely, LL, LH, HL, and HH. A high-frequency sub band contains the high frequency component of the image [11]. In order to preserve more edge information i.e. obtaining a sharper enhanced image, have proposed an intermediate stage in high frequency sub band interpolation process. The Bicubic interpolation method is used in this process. This sharpness is boosted by the condition that, the interpolation of isolated high-frequency components in HH, HL, and LH will preserve more high-

frequency components than interpolating the low-resolution image directly [1]. This operation results in four decomposed sub band images referred to low low (LL), low-high (LH), high-low (HL), and high-high (HH). The frequency components of those sub bands cover the full frequency spectrum of the original image. Estimated high frequency components are formed by using interpolation of high frequency components with difference image. Inverse Discrete wavelet transform of the estimated sub-bands gives the resolution enhanced image.

3.2 Materials and Methods

I collected satellite images for the study from Google map, from standard data set and matlab is used for simulating the algorithms. Estimated sub-bands are interpolated to get estimated sub-band. Inverse DWT is used to obtained enhanced image the proposed method is simulated on the matlab.

3.3 Advantages of Proposed Method

- 1) Superior Resolution, when compared to existing techniques.
- 2) Greater PSNR ratio.
- 3) PSNR, RMSE and visual result shows superiority of proposed method over.
- 4) Conventional state of art technique.
- 5) Edge information of image is preserved.
- 6) No of pixels are more than the conventional techniques of image enhancement.

4 Expected Result

For the satellite image resolution enhancement purpose different data set is used for the purpose of analyzing the resolution enhancement. I test these images with different image resolution size like 150X150 to 300X300.

4.1 Result Parameter

Peak signal-to-noise ratio (PSNR) and root mean square error (RMSE) have been implemented in order to obtain some quantitative results for comparison. PSNR can be obtained by using the following formula,

$$PSNR = 10 \log_{10} \frac{R^2}{MSE} \quad (4.1)$$

Where R is the maximum fluctuation in the input image. PSNR gives the peak signal to noise ratio and MSE is representing the MSE between the given input image I in and the original image I or g which can be obtained by the following [1, 10]

$$MSE = \frac{\sum_{i,j} (\ln(i,j) - \text{org}(i,j))^2}{M \times N} \quad (4.2)$$

where M and N are the size of the images.

$$RMSE = \sqrt{\frac{\sum_{i,j} (\ln(i,j) - \text{org}(i,j))^2}{M \times N}} \quad (4.3)$$

4.2 Bilinear Interpolation Method Result

Graphical User Interface for the Bilinear interpolated method shows original input low resolution window. Enhanced output image window. It shows the input image resolution output image resolution and image parameters

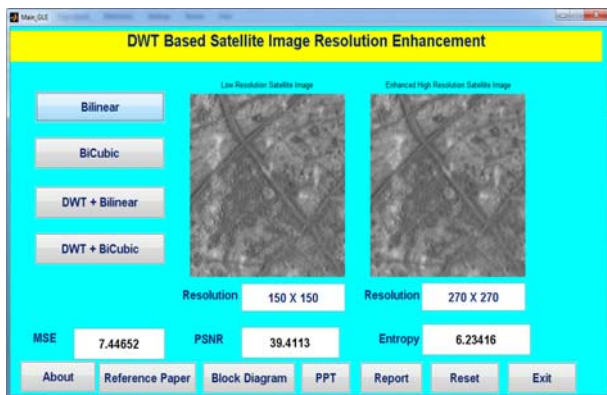


Fig 4.1: Software Environment for Bilinear Method

4.3 Bicubic Interpolation Method Result

GUI for the Bicubic interpolation method is shown below figure 5.2 it shows shows original input low resolution

window. Enhanced output image window. It shows the input image resolution output image resolution and image parameters

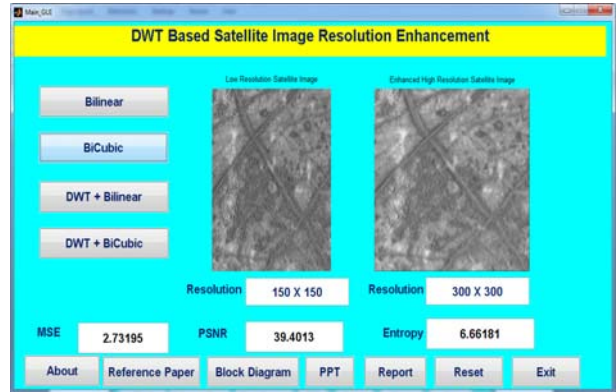


Fig 4.2: Bicubic Interpolation and Result parameter

4.4 DWT Based Bilinear Interpolation Method Result

Graphical User Interface for the DWT-Based Bilinear interpolated method shows original input low resolution window. Enhanced output image window. It shows the input image resolution output image resolution and image parameters

Above figure shows the output for DWT Based Bilinear interpolation method. It shows the selected low resolution input image. This image is enhanced in resolution by the technique of DWT Based Bilinear interpolation method. The input low resolution image is of 200X200 in size. The enhanced image is 398X398 in size.

RMSE of the image is 2.80476, PSNR is 39.1737, and Entropy is 5.79738. The DWT Based interpolation is good for the improve the RMSE and PSNR. DWT Based Bilinear interpolation is quite Complicated method to enhance the low resolution of image this method is better than the bilinear and Bicubic interpolation method to enhance the low resolution image.



Fig 4.3: DWT- Based Bilinear Interpolation and Result parameter

4.5 DWT Based Bicubic Interpolation Method Result

Below figure shows the output for DWT Based Bicubic interpolation method. It shows the selected low resolution input image. This image is enhanced in resolution by the technique of DWT Based Bicubic interpolation method. The input low resolution image is of 200X200in size. The enhanced image is 398X398 in size. RMSE of the image is 2.80476, PSNR is 39.1737, and Entropy is 5.79738. The DWT Based Bicubic interpolation is good for the improve the

RMSE and PSNR. DWT Based Bicubic interpolation is quite complicated method to enhance the low resolution of image this method is better than the bilinear and Bicubic interpolation method to enhance the low resolution image. Bicubic interpolation method maintain the sharp edges of images after

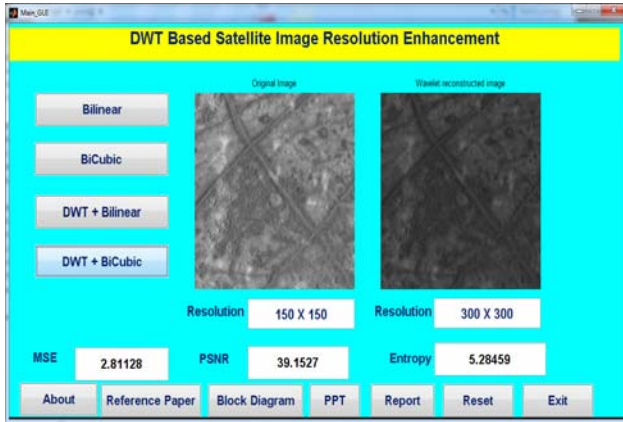


Fig 4.4: DWT- Based Bicubic Interpolation and Result Parameter

4.6 Comparison of Result Parameter with different Methods

Result parameters like PSNR, ENTROPY, RMSE of different Methods are compared in this section.

4.6.1 Comparative study of PSNR

The Table No 4.1 shows comparative study of different methods. The parameter used for the comparison is PSNR (Db) the Enhancement is done of image from 150X150 image to 300x300

Table 6.1: Comparative study of PSNR

Sr. No.	Method	PSNR(dB)
1	Bilinear	39.411
2	Bicubic	39.4013
3	DWT+Bilinear	39.1737
4	Proposed Method	39.1527

The above table shows the different methods and their PSNR. From this method the proposed method has high PSNR than other methods [1]

4.6.2 Comparative Study of Entropy

The table no 4.2 shows comparative study of different methods with proposed techniques the parameter study done in conversion of 150x150 to 300x300 image size.

Table 6.2: Comparative Study of Entropy

Sr. No.	Method	ENTROPY
1	Bilinear	6.234
2	Bicubic	6.66181
3	DWT+Bilinear	5.79738
4	Proposed Method	5.28459

4.6.3 Comparative study of RMSE

RMSE result for resolution enhancement from 150x150 to 300x300 for the proposed technique compared with conventional and some state of art techniques.

Table 6.3: Comparative Study of RMSE

Sr. No.	Method	RMSE
1	Bilinear	7.446
2	Bicubic	2.731
3	DWT+Bilinear	2.80486
4	Proposed Method	2.81128

Above table shows the comparative study of ENTROPY and RMSE parameter the entropy parameter for proposed method is better than other methods. Similarly RMSE comparative study also gives the improvement for proposed method

5 Conclusions

5.1 Conclusion

There are a number of techniques that can be used to enlarge an image. The performance of bilinear interpolation method, nearest- neighbor method and Bicubic interpolation method studied for satellite image enhancement. Bilinear interpolation is simplest method. Bilinear interpolation is 2D version of linear interpolation. Bicubic interpolation is important for the edges enhancement and getting the harp edge image. The proposed method will give the enhanced result than the other image enhancement techniques. The edges of the image will enhanced with accuracy by proposed techniques. The proposed technique will give clear image than the other techniques. This work has proposed a new resolution enhancement technique based on the interpolation of the high-frequency sub band images obtained by DWT and the input image. The proposed technique can be tested on well-known images. Improvement in MSE and RMSE also expected by proposed method.

5.2 Future Scope

Future work includes the extension of this method to Image Resolution Enhancement from videos where not only static image but also other information such as motion or context information is available. Again the future work includes extension of proposed method images with very low Resolution.

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