DWT-Based Satellite Image Resolution Enhancement

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Abstract— Satellite images are being used in many fields of research. One of the major issues of these types of images is their resolution. So it is essential to have high resolution satellite images. Resolution enhancement of these images has always been a major issue to extract more information from them. Wavelet domain based methods have proved as most efficient technique serving 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 are nearest neighbor, bilinear and bicubic interpolation .several image enhancement techniques have been proposed. In this paper, I propose 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.

Key words: Discrete Wavelet Transforms (DWT), Interpolation, Satellite Image Resolution Enhancement, Wavel

I. Introduction

Resolution of an image plays very important role in many image and video-processin applications, such as video resolution enhancement, feature extraction, and satellite image resolution enhancement [1]. Because of the low frequency nature of satellite image, it may appeared as blurred image. To improve the frequency of those images, image Resolution techniques are used. Enhancing the resolution of an image includes improving the number of pixels available to represent the details of image. This work analyses the performance of various image resolution techniques for satellite images. The techniques are compared based on Mean Squared Error and Peak Signal to Noise Ratio.

Interpolation in image processing is a method to increase the number of pixels in a digital image. Interpolation has been widely used in many image processing applications, such as facial reconstruction, multiple description coding, and image resolution enhancement [1]. The interpolation-based image resolution enhancement has been used for a long time. Interpolation has been widely used in many image processing applications, such as facial reconstruction [6], multiple description coding and image resolution enhancement many interpolation techniques have been developed to increase the quality of this task. There are three well-known interpolation techniques, namely, nearest neighbor, bilinear, and bicubic. Bicubic interpolation is more sophisticated than the other techniques and produces smoother edges. Wavelets are also playing a significant role in many image processing applications. The 2-D wavelet decomposition of an image is performed by applying the 1-D discrete wavelet transform (DWT) along the rows of the image first, and then The results are decomposed along the columns. 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. a resolution-enhancement technique use of interpolated DWT high-frequency sub band images and the input low-resolution image. Then the Inverse DWT is done to obtain enhanced image [1].

II. Method of Analysis

A. *DWT-Based Resolution Enhancement:*

A new satellite image resolution and brightness enhancement technique based on the discrete wavelet transform (DWT) has been proposed. 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. The technique also estimates the singular value matrix of the low–low sub band of histogram equalized image and normalize both singular value matrices to obtain brightness enhanced image. 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.

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 intermediate process of adding the difference image, containing high-frequency components, generates significantly sharper and clearer final image. 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. The 2-D wavelet decomposition of an image is performed by applying the 1-D discrete wavelet transform (DWT) along the rows of the image first, and then the results are decomposed along the columns. 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. Theoretically, a filter bank shown in figure 1 should operate on the image in order to generate different sub band frequency images [1]

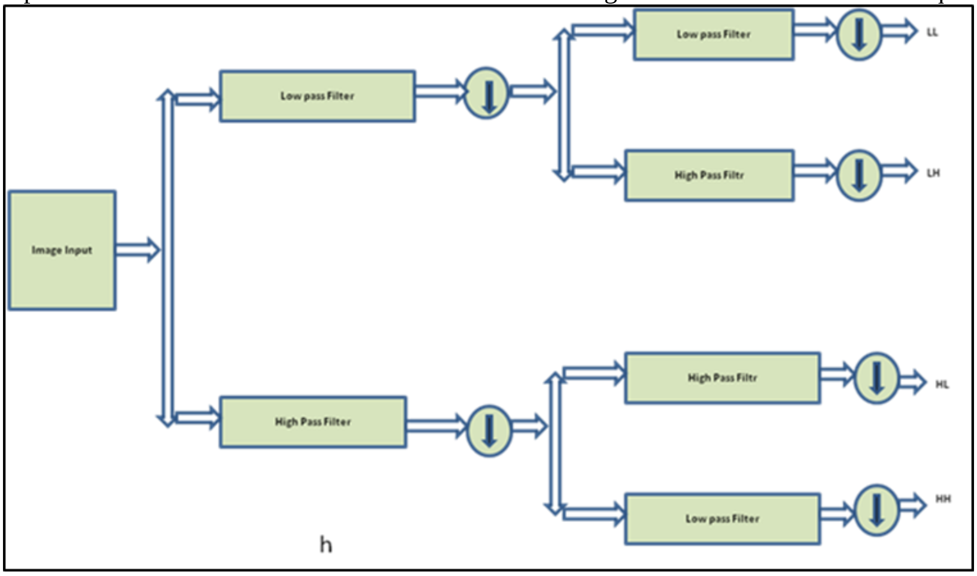

Fig. 1: Block Diagram of DWT Filter Banks of Level1

I propose a resolution-enhancement technique using interpolated DWT high-frequency sub band images and the input low-resolution image. Inverse DWT (IDWT) has been applied to combine all these images to generate the final resolution-enhanced image. In order to achieve a sharper image, we propose to use an intermediate stage for estimating the high frequency sub bands by utilizing the difference image obtained by subtracting the input image and its interpolated LL sub band. The proposed technique has been compared with standard interpolation techniques, wavelet zero padding (WZP), where the unknown coefficients in high-frequency sub bands are replaced with zeros, and state-of-art techniques, such as WZP and cycle spinning (CS) , and complex wavelet transform (CWT)-based image resolution enhancement . in this report the resolution enhancement is used as a process that enlarges the given input in the way that the output is sharper. The performance of the proposed technique is better over performs all available state-of-art methods for image resolution enhancement.

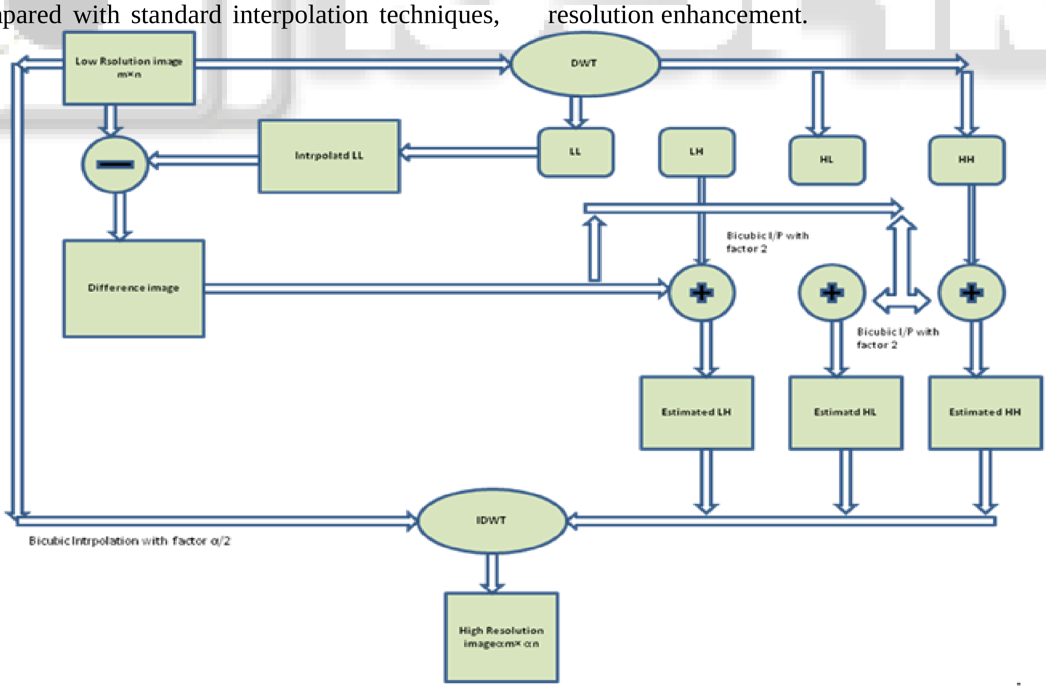

Fig. 2: Block Diagram of the Proposed Resolution Enhancement Algorithm

Figure 3 shows different sub bands of a satellite image where the top left image is the LL sub band, and the bottom right image is the HH sub band. Improve the sharpness of the reconstructed images. Their estimation was carried out by investigating the evolution of wavelet transform extreme among the same type of sub bands. Edges identified by an edge detection algorithm in lower frequency sub bands were used to prepare a model for estimating edges in higher frequency sub bands and only the coefficients with significant values were estimated as the evolution of the wavelet coefficients.

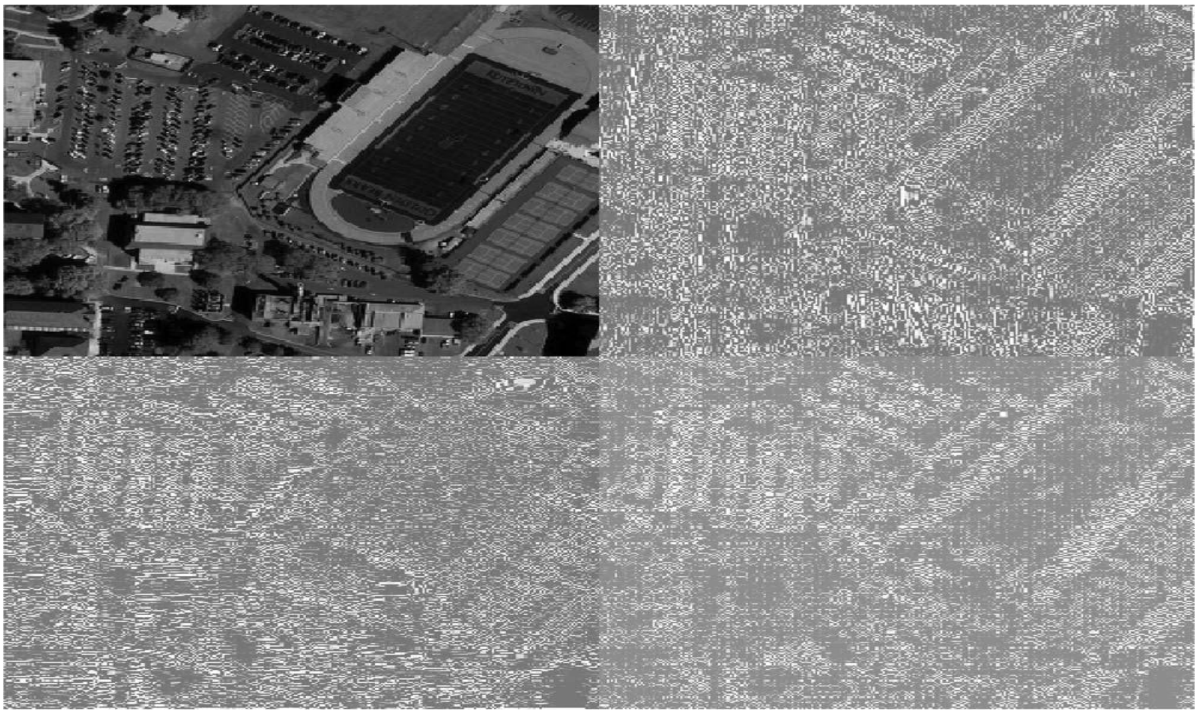

Fig. 3: LL, LH, HL, and HH Subbands of a Satellite Image Obtained By Using DWT.

To preserve the high-frequency components of the image. DWT separates the image into different subband images, namely, LL, LH, HL, and HH. High-frequency sub-bands contains the high frequency component of the image. The interpolation can be applied to these four subband images. In the wavelet domain, the low-resolution image is obtained by low-pass filtering of the high-resolution. The low-resolution image (LL subband), without quantization (i.e. with double-precision pixel values) is used as the input for the proposed resolution enhancement process. In other words, low frequency sub-band images are the low resolution of the original image. Therefore, instead of using low-frequency subband images, which contains less information than the original input image, we are using this input image through the interpolation process. Hence, the input low-resolution image is interpolated with the half of the interpolation factor, $\alpha/2$, used to interpolate the high-frequency subbands, as shown in Figure 3. In order to preserve more edge information, i.e., obtaining a sharper enhanced image, I have proposed an intermediate stage in high frequency sub band interpolation process. As shown in Figure 2. The low-resolution input satellite image and the interpolated LL image with factor 2 are highly correlated. The difference between the LL subband image and the low-resolution input image are in their high-frequency components. Hence, this difference image can be use in the intermediate process to correct the estimated high-frequency components. This estimation is performed by interpolating the high-frequency sub bands by factor 2 and then including the difference image (which is high-frequency components on low-resolution input image) into the estimated high-frequency images, followed by another interpolation with factor $\alpha/2$ in order to reach the required size for IDWT process. The intermediate process of adding the difference image, containing high-frequency components, generates significantly sharper and clearer final image. This sharpness is boosted by the fact 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.

The proposed technique has been tested on several different satellite images. In order to show the superiority of the proposed method over the conventional and state-of-art techniques from visual point of view.In those figures with low-resolution satellite images, the enhanced images by using bicubic interpolation, enhanced images by using WZP and CS-based image resolution enhancement, and also the enhanced images obtained by the proposed technique are shown. It is clear that the resultant image, enhanced by using the proposed technique, is sharper than the other techniques[1].

B. *Interpolation:*

Interpolation is the process of estimating the values of a continuous function from discrete samples. Image processing applications of interpolation include image magnification or reduction, subpixel image registration, to correct spatial distortions, and image decompression, as well as others. Of the many image interpolation techniques available, nearest neighbor, bilinear and cubic convolution are the most common, Since Interpolation provides a perfect reconstruction of a continuous function I wish to use the interpolation in my paper and project with the DWT method it gives the better effect for the image enhancement. the bicubic interpolation method helps the prevent the edges sharpness of images therefore bicubic interpolation method is employed here.

1) *Cubic Convolution 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 Neighbors

Interpolation. First, four one-dimension cubic convolutions are performed in one direction and then one more one-dimension cubic convolution is performed in the perpendicular direction . This means that to implement a two-dimension cubic convolution, a one-dimension cubic convolution is all that is needed. For one-dimension Cubic Convolution Interpolation, the number of grid points needed to evaluate the interpolation function is four, two grid points on either side of the point under consideration. For Bicubic Interpolation (cubic convolution interpolation in two dimensions), the number of grid points needed to evaluate the interpolation function is 16, two grid points on either side of the point under consideration for both horizontal and vertical directions. The grid points needed in one-dimension and two-dimension cubic convolution interpolation are shown in Figure 4.

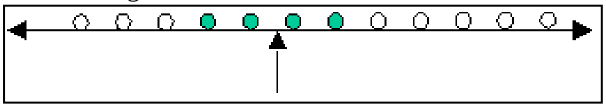

Fig. 4: (a)

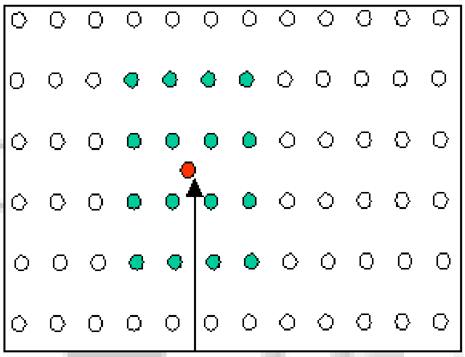

Fig. 4 (b)

Fig. 4: Grid Point in (A) One Dimensional (B) In Two Dimensional Cubic Convolution Interpolation

Figure.4: grid point in (a) one dimensional (b) in two dimensional cubic convolution interpolatio

C. Matlab's Implementation of Bicubic Interpolation:

Fig. 5: Matlab's Implementation of Bicubic Convolution Interpolation.

D. Advantages of Proposed Method:

- Superior Resolution, when compared to existing techniques.
- Greater performance Ratio.

III. COMPARISON OF RESULTS

A. Comparative Study of PSNR:

The following table shows comparative study of different mthods . the parameter used for the comparison is PSNR (Db) the Enhancement is done from 128*128 image to 512*512.

Sr No	Method	PSNR(dB)
01	Bilinear	19.07
02	Bicubic	20.16
03	Proposed Method	24.97

Table 1: Comparative Study of PSNR

B. Comparative Study of ENTROPY:

The following table shows comparative study of different mthods . The parameter used for the comparison is ENTROPY the Enhancement is done from 128*128 image to 512*512

Sr No	Method	Entropy
01	Low Resolution Satllite Image	2.975
02	Original High Satellite image	5.968
03	Proposed Method	5.937

Table 2: Comparative Study of Entropy

IV. CONCLUSIONS

There are a number of techniques that can be used to enlarge an image. The performance of bilinear interpolation method, nearest neighbor method for satellite image enhancement, Bicubic interpolation method studied. The proposed method gives the better result than the other image enhancement techniques. The edges of the image are enhanced with accuracy in proposed 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 has been tested on well-known images, where their PSNR and RMSE and visual results show the superiority of the proposed technique over the conventional and state-of-art image resolution enhancement techniques. The PSNR improvement of the proposed technique is up to 7.19 dB compared with the standard Bicubic interpolation. The three most common enhancement techniques are presented here. Keys implementation of Bicubic Convolution Interpolation gave the best results in terms of image quality Keys implementation was shown to be equivalent to that of Matlab.

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