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Improvement of Satellite Image Resolution Using Discrete Wavelet Transform

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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. In this paper, we propose a new satellite image resolution enhancement technique based on discrete wavelet transform(DWT). The proposed technique uses DWT to decompose the input image into different sub bands. Then, the LL sub-band and estimated high frequency sub-band images are combined to generate a new resolution-enhanced image by using inverse DWT. In order to achieve sharper image, an intermediate stage for estimating the high frequency subbands has been proposed. The proposed technique has been tested on satellite image. The quantitative (peak signal-to-noise ratio and root mean square error) and visual results show the superiority of the proposed technique over the existing image resolution enhancement technique. Also faster and simpler implementation is proposed compared to one mentioned in [3]**

Index terms-- Discrete wavelet transform (DWT), Satellite image resolution enhancement.

I.INTRODUCTION

RESOLUTION of an image has been always an important issue in many image- and video-processing applications, such as video resolution enhancement, and satellite image resolution enhancement[2].

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. Theoretically, a filter bank shown in Fig.1.should operates on the image in order to generate different sub-band frequency images. Fig.2. shows the 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.

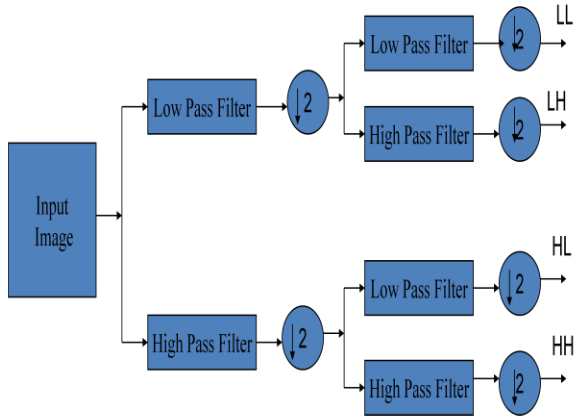

Fig.1. Block diagram of DWT filter banks of level-I

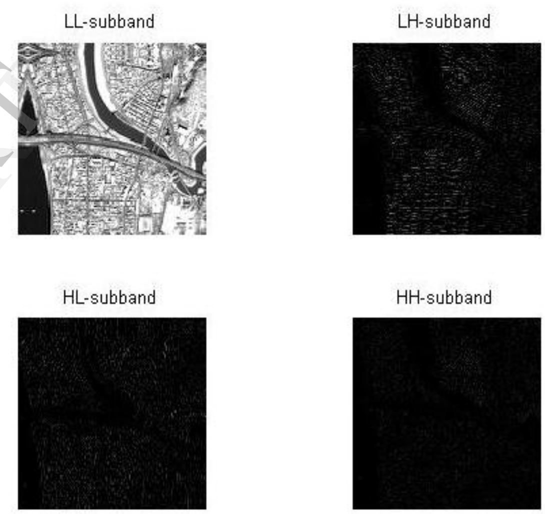

Fig.2. LL, LH, HL, and HH sub-bands of a satellite image obtained by using DWT.

II. WAVE-LET BASED IMAGE RESOLUTION ENHANCEMENT USING DWT

There are several methods which have been used for satellite image resolution enhancement. In this paper, we have used satellite image resolution enhancement using DWT.

Interpolation-Based Image Resolution Enhancement Using DWT.

In this technique, the main loss of an image after being resolution enhanced by applying interpolation is on its high frequency components, which is due to the smoothing caused by interpolation. Hence, inorder to increase the quality of the enhanced image, preserving the edges is essential. In this technique, Dwt has been employed to preserve the high-frequency components of the image. The interpolation can be applied to four(LL,LH,HL and HH) sub-band images.

High frequency sub-bands contains the high-frequency component of the image. The interpolation can be applied to these four sub-band images. In the wavelet domain, the low-resolution image is obtained by low-pass filtering of the high-resolution image as in. The low resolution image (LL sub-band), 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 sub-band 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 sub-bands, as shown in Fig. 5. In order to preserve more edge information, i.e., obtaining a sharper enhanced image, we have proposed an intermediate stage in high frequency sub-band interpolation process. As shown in Fig. 5, the low-resolution input satellite image and the interpolated LL image with factor 2 are highly correlated. The difference between the LL sub-band image and the low-resolution input image are in their high-frequency components. Hence, this difference image can be used in the intermediate process to correct the estimated high-frequency components. This estimation is performed by interpolating the high-frequency subbands 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.

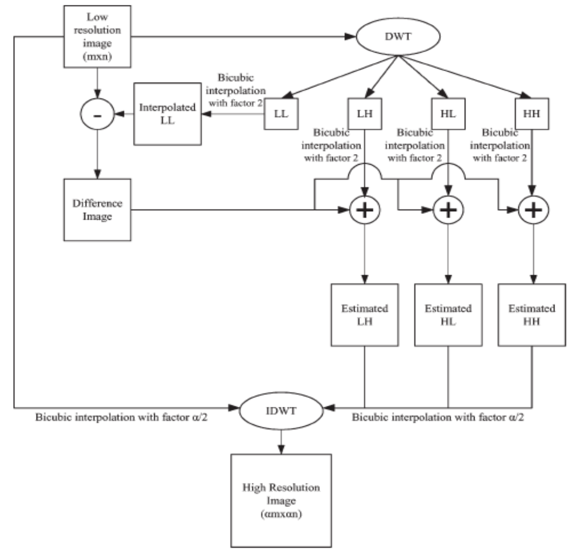

Fig.3. Block diagram of resolution enhancement technique based on interpolation using DWT algorithm.

III. DWT-BASED IMAGE RESOLUTION ENHANCEMENT

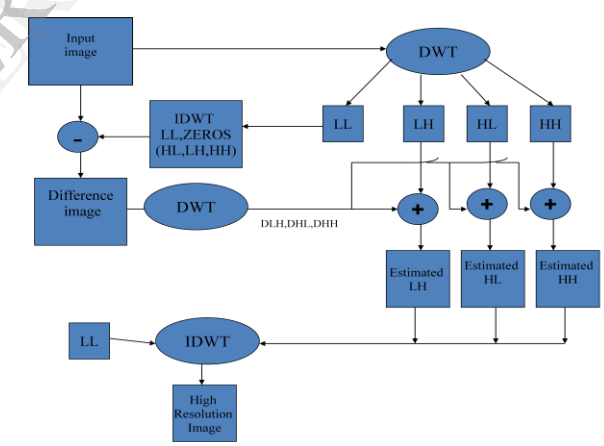

Fig.4. Block diagram of resolution enhancement technique based on DWT algorithm.

As it was mentioned before, resolution is an important feature in satellite imaging which makes the resolution enhancement of such images to be of vital importance as increasing the resolution of these images will directly affect the performance of the system using these images as input. The satellite image in pixel domain used as input for this method. In order to increase the quality of the enhanced image, reserving the edges is essential. In this paper, DWT has been employed inorder to preserve the high frequency components of the image. DWT separates

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the image into different sub-band images, namely, LL, LH, HL and HH. High-frequency subband images contain the high frequency component of the image. The LL sub-band and zeros of size of high frequency sub-band are combined using inverse DWT, the resultant image and the input image are highly correlated. The difference of these two is in their high-frequency components. Hence, this difference can be used in estimating the high-frequency components. This estimation is performed by adding high-frequency components of difference image to corresponding high-frequency bands of input image. Then, a sharper enhanced image is obtained by combining estimated sub-bands and LL sub-band of the input image using inverse DWT. The intermediate process of adding the difference image, containing high-frequency components, generates significantly sharper and clearer final image.

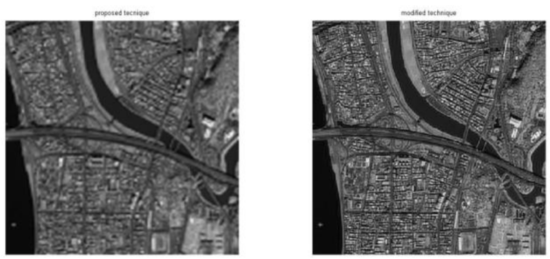

Fig.5.Shows comparison of proposed (existing) and modified technique

Fig.6.Shows comparison of input and proposed (existing) technique.

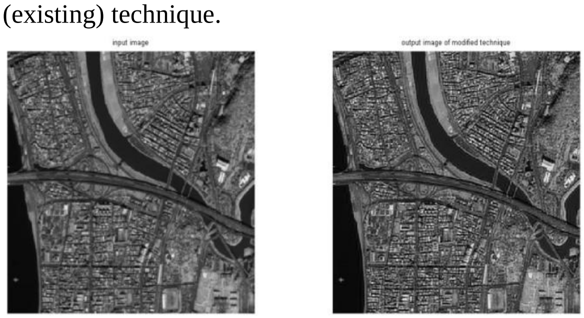

Fig.7.Shows comparison of input and modified technique.

IV. RESULTS AND DISCUSSIONS

The proposed technique has been tested on satellite input mage. In order to show the superiority of the proposed method over the existing technique from visual point of view are included. It is clear that the resultant image, enhanced by using the proposed technique, is sharper than the other techniques.

PSNR can be obtained by using the following formula:

$$PSNR=10\log10(R*R/MSE) \quad (1)$$

Where R is the maximum fluctuation in the input image (255 in here as the images are represented by 8 bit, i.e., 8-bit grayscale representation have been used); and MSE is representing the MSE between the given input image and the original image which can be obtained by the following

$$MSE=sum\ (Input\ image-original\ image)^2/(M*N) \quad (2)$$

Where M * N is the size of images. Clearly, RMSE is the square root of MSE; hence it can be calculated by the following:

$$RMSE = \sqrt{(MSE)} \quad (3)$$

V. CONCLUSION

This paper has proposed a new resolution enhancement technique based on DWT and the input image. The proposed technique has been tested on image, where their PSNR and RMSE and visual results show the superiority of the proposed technique over the existing image resolution enhancement technique. The PSNR improvement of the proposed technique is up to 12 dB compared with existing method.

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