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A Novel Approach for Satellite Image Resolution Enhancement

E. Mohan, K.B. Jayarraman, U. Maheswaran, D. Sathiyaraj. G. Dhakshanamoorthi

Abstract—Image resolution is an important issue in satellite imaging. Wavelets play a significant role in multi resolution analysis. In this paper, a new resolution enhancement technique is proposed. This method is based on interpolation of the high frequency sub-bands which are obtained by performing Discrete Wavelet Transform (DWT) on input image. DWT separates the image in to different sub-band images namely, low-low (LL), low-high (LH), high-low (HL) and high-high (HH). 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. The low-resolution image (LL sub-band) is used as input for the proposed resolution enhancement process. The high frequency sub-bands contain the high frequency components of image .Interpolation is carried out using Adjacent pixel algorithm and Inverse Discrete Wavelet Transform(IDWT) has been applied to combine all these images to generate the final super-resolved image. This approach generates sharper and clearer image. The proposed technique has shown superiority over the conventional image resolution enhancement techniques.

Index Terms—Adjacent Pixel algorithm, DWT (discrete wavelet transform), Image Enhancement, Interpolation, Adjacent Pixel algorithm

I. INTRODUCTION

Image Enhancement is an important application in field of image processing; and a critical one when it comes to enhancing satellite image at a resolution higher than that at which image is available. Image interpolation addresses the problem of generating a high resolution image from its low resolution version.

A common feature of wavelet domain image resolution enhancement algorithm is the assumption that LR image to enhance is the LP filtered sub-band of high resolution image which has been subjected to decimated wavelet transform. In this paper, we propose a novel image resolution enhancement technique for satellite images. The proposed technique uses DWT to decompose a low resolution image in to different sub-band images. Then the four high-frequency sub-band images are interpolated using bicubic interpolation.

In parallel, the low resolution input image is also interpolated separately. Finally, the interpolated high frequency sub-band images and interpolated input image are combined using inverse DWT (I-DWT) to achieve a high resolution-output image. The resolution enhancement methods in wavelet domain are very significant for enlarging image size.

In the following section we discuss about the related works in section II, proposed system in section III and about the index terms in the section IV, V, VI, conclusion in VII respectively.

II. RELATED WORK

In this section we review past work relevant to the image resolution enhancement. A literature survey in this area finds a significant amount of work in knowing about different techniques employed in enhancing the resolution of the images. In each case we summarize the approach and highlight any noteworthy contributions, assumptions, or limitations.

H. Demirel et al in [1] proposed a technique which uses DT-CWT to decompose an image into different sub-band images, and then the high-frequency sub-band images are interpolated. An original image is interpolated with half of the interpolation factor used for interpolation of the high-frequency sub-band images. Then, all these images are combined using IDT-CWT to generate a super resolved image. Similarly Y. Piao et al, [2] have employed a new image resolution enhancement method in wavelet domain using inter-sub-band correlation. This method utilized the correlation of sub-bands with different sampling phases in DWT. The high frequency bands were estimated with filters designed in the lower level under the assumption that filters connecting two bands are similar in different levels. This motivates us to design a general filter set well adapts to all images, since estimation of filters for each frame is time consuming when applied to video sequence.

X. Li in [3] developed a novel edge-directed interpolation algorithm. The interpolation is adapted by the local covariance and covariance-based adaptive interpolation is proposed to alleviate the burden of the computational complexity. It demonstrates significant improvements over linear interpolation on visual quality of the interpolated image. In [4] C. B. Atkins et al have introduced a new approach to optimal image scaling called Resolution Synthesis (RS). In RS, the pixel being interpolated is first classified in the context of a window of neighboring pixels; and then the corresponding high-resolution pixels are Obtained by filtering with co-efficient that depends upon the classification.

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***** Correspondence Author (s)
E.Mohan, Head, Department of Computer Science and Engineering, Pallavan College of Engineering, Kanchipuram, India.
Dr.K.B.Jayarraman, Head, Department of Computer Science and Engineering,, ManakulaVinayagar Institute of Technology, Pudhuchery, India.
U.Maheswaran, Assistant Professor, Department of Electronics and Communication Engineering,, Pallavan College of Engineering, Kanchipuram, India.
D.Sathiyaraj, Assistant Professor, Department of Electronics and Communication Engineering,, Pallavan College of Engineering, Kanchipuram, India.
G. Dhakshana Moorthi, PG Scholar, Department of Computer Science and Engineering,, ManakulaVinayagar Institute of Technology, Pudhuchery, India.

They present a simple derivation to show that RS generates the minimum mean-squared error (MMSE) estimate of the high-resolution image, given the low resolution image.

In [5] G. Anbarjafari proposed to use the super resolution on different sub-bands of localized moving regions extracted from DWT and decomposing the super resolved sub-bands using IDWT to generate the respective enhanced high resolution frame. A. Temizel in [7] have presented a method which estimates local edge orientation from a wavelet decomposition of the available LR image and uses this information to influence CS parameters. A. Temizel in [8] used an image resolution enhancement algorithm operating in the wavelet domain. The proposed algorithm aims to alleviate the main drawback of HMT based wavelet coefficient estimation methods.

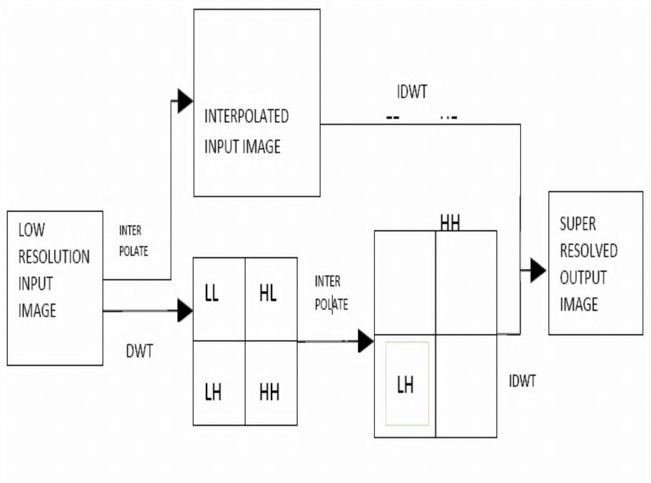

Figure 1.Block Diagram of proposed solution

H. Demirel, G. Anbarjafari, et al [6]Have used the super resolution on different sub-bands of localized moving regions extracted from DWT and composing the super resolved sub-bands using IDWT to generate the respective enhanced high resolution frame. The improvement is achieved isolating different frequencies in different sub bands extracted from DWT and super resolving them separately.

III. PROPOSED SYSTEM

Dwt Based Satellite Image Resolution Enhancement

In this work, we propose to use super resolution on different sub-bands extracted from DWT and composing the super resolved sub-bands using Inverse DWT (I-DWT) to generate the respective enhanced high resolution image.The main loss of an image after being resolution enhanced by applying interpolation is on its high-frequency components, which is due to smoothing caused by interpolation. In order to increase the quality of enhanced image, preserving the edges is essential.

The wavelet transform however provides a means by which the local smoothness of a signal may be quantified. In wavelet Domain, the low-resolution image is obtained by low pass filtering of high resolution image. Thus, low frequency sub-band images are low resolution of the original images.

Therefore, instead of using low-frequency Sub-band images which contain less information than the original input image, we are using the input image for the interpolation of two low frequency sub-band images. Hence using input image increases the quality of super-resolved image. The Input image is interpolated with half of the interpolation factor α used to interpolate the high-frequency sub bands, as illustrated in fig1. By interpolating the Input image and high frequency components by α/2 and then by applying Inverse DWT(I-DWT), the output image will contain sharper edges than the interpolated image obtained by interpolation of Input image directly.

IV. DISCRETE WAVELET TRANSFORMS (DWT)

The wavelet transform provides a time-frequency representation of the signal. The signal to be analyzed is passed through filters with different cut-off frequencies at different scales. The resolution of signal, which is the measure of amount of detail information in the signal, is determined by the filtering operations, and the scale is determined by up-sampling and down-sampling operations. The DWT is computed by successive low pass filtering of input image .The 2D-Wavelet decomposition of an image is performed by applying 1D-Wavelet transform along rows of Image. Results are decomposed along columns. This operation results in four sub-band images referred to as LL, LH, HH, HL. The frequency components of those sub bands cover the full frequency spectrum of original image. DWT is employed to preserve the high frequency components. Fig 2 shows different sub-bands of a satellite image where the top left image of the LL sub-band and the bottom right image is the HH sub-band.

Figure. 2 Decomposition of sub-bands

V. INTERPOLATION OF WAVELET TRANSFORMED IMAGES

It is the method to increase the number of pixels in digital image. We make use of adjacent pixel (AP) algorithm to perform interpolation of wavelet transformed images. In this algorithm, we initially add an extra column to LL sub-band and assign the average pixel value of the nearest neighboring pixels. Neighboring pixels. This can be shown in fig 3.Then interpolation is applied to remaining subbands.

Algorithm AP

INPUT : Discrete Wavelet Transformed Image
OUTPUT: Interpolated image
Begin
1. Take LL sub-band
2. Add a new empty column
3. Assign pixel value by computing average of nearest Neighboring pixels.
4. Goto step 2
5. Repeat for all sub-bands
End

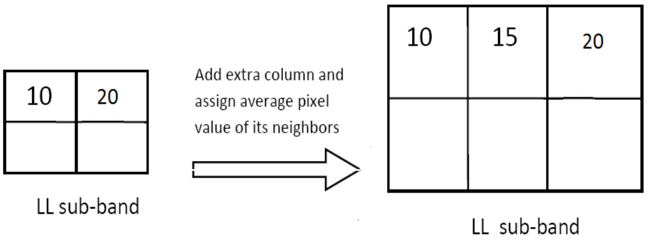

Fig. 3 Adjacent pixel algorithm

VI. INVERSE DISCRETE WAVELET TRANSFORMATION (IDWT)

It performs the reverse operation of DWT. Inverse DWT (I-DWT) has been applied to combine all the high frequency sub-band images and the low resolution input image to obtain a final resolution enhanced image.

In this process components can be assembled back into the original signal without loss of information. This process is called reconstruction, or synthesis and the mathematical manipulation that effects synthesis is called the IDWT.

IDWT reconstructs a signal from the approximation and detail coefficients derived from decomposition. The IDWT differs from the Discrete Wavelet Transform (DWT) in that it requires up-sampling and filtering, in that order. Up sampling means the inserts zeros between samples in a signal.

VII. CONCLUSION

The wavelet-based interpolation method described in this paper avoids problems caused by conventional interpolation methods. The improvement is achieved by isolating different frequencies in different sub-bands extracted from DWT and super resolving them separately. The original image is interpolated with half of the interpolation factor used for interpolation of high frequency sub-band image. Then these entire images are combined using Inverse DWT (I-DWT) to generate super resolved image. The proposed algorithm aims to preserve more edge information.

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