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Image Super Resolution Enhancement Based on Interpolation of Discrete and Stationary Wavelet Domain

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Abstract - **In this paper, we propose an image super resolution enhancement technique based on interpolation of the high frequency sub band images obtained by discrete wavelet transform (DWT) using different types of wavelets such as Daubechies 1. Daubechies 2 …., Daubechies 9 haar, and the input image. The edges are enhanced by introducing an intermediate stage by using stationary wavelet transform (SWT). We compare the results of different types of wavelets. DWT is applied in order to decompose an input image into different sub bands. Then the high frequency sub bands as well as the input image are interpolated. The estimated high frequency sub bands are being modified by using high frequency sub bands obtained through SWT then all these sub bands are combined to generate a new super-resolved image by using inverse DWT.**

Keywords - **Discrete Wavelet Transform, Image super resolution, Stationary Wavelet Transform**

I. Introduction

Image resolution describes the detail an image holds. The term applies to raster digital images, film images, and other types of images. Higher resolution means more image detail. Image resolution has been frequently referred as an important aspect of an image. Images are being processed in order to obtain more enhanced resolution. One of the commonly used techniques for image resolution enhancement is Interpolation. Interpolation in image processing is a method to increase the number of pixels in a digital image. Image interpolation generates a larger image from a smaller size image Interpolation has been widely used in many image processing applications such as facial reconstruction [1], multiple description coding [2], and super resolution [3]-[6]. Interpolation-based super resolution has been used for a long time,and many interpolation techniques have been developed to increase the quality of this task. There are three well known interpolation techniques, namely nearest neighbor interpolation, bilinear interpolation, and bicubic interpolation. Image resolution enhancement in the wavelet domain is a relatively new research topic and recently many new algorithms have been proposed [4]-[7].Discrete wavelet transform (DWT) [8] is one of the recent wavelet transforms used in image JIn this work, we are proposing an image resolution enhancement technique which generates sharper high resolution image. The proposed technique uses DWT to decompose a low resolution image into different subbands. Then the three high frequency subband images have been interpolated using bicubic interpolation. The high frequency sub bands obtained by SWT of the input image are being incremented into the interpolated high frequency sub bands in order to correct the estimated coefficients.

In parallel, the input image is also interpolated separately. Finally, corrected interpolated high frequency sub bands and interpolated input image are combined by using inverse DWT (IDWT) to achieve a high resolution output image. The proposed technique has been compared with conventional and state-of-art image resolution enhancement techniques.

The conventional techniques used are the following:

A)Interpolation techniques:namely, nearest interpolation, bilinear interpolation,&bicubic interpolation;

B)Wavelet zero Padding (WZP) :

The state-of-art techniques used for comparison purposes are the following:

- regularity-preserving image interpolation[7];
- new edge-directed interpolation (NEDI)[10];
- hidden Markov model (HMM) [11];
- HMM-based image super resolution (HMM SR) [12];
- WZP and cycle-spinning (WZP-CS) [13];
- WZP, CS, and edge rectification (WZP-CS-ER) [14];
- DWT based super resolution (DWT SR) [15];
- complex wavelet transform based super resolution (CWT SR) [15];

Some of the aforementioned state-of-art techniques [7], [11]-[14], use DWT for image super resolution. According to the quantitative and qualitative experimental results, the proposed technique performs the aforementioned conventional and state-of-art techniques for image resolution enhancement.

II. Proposed Image Resolution Enhancement

In image resolution enhancement by using interpolation the main loss is on its high frequency components (i.e., edges), which is due to the smoothing caused by interpolation. In order to increase the quality of the super resolved image, Preserving the edges is essential. In this work, DWT has been employed in order to preserve the high frequency components of the image. The redundancy and shift invariance of the DWT mean that DWT coefficients are inherently interpolable [9]. In this correspondence, one level DWT(with Daubechies 9/7 as wavelet function) is used to decompose an input image into different sub band images. Three high frequency sub bands (LH, HL, and HH) contain the high frequency components of the input image. In the proposed technique, bicubic interpolation with enlargement factor of 2 is applied to high frequency sub band images. Down sampling in each of the DWT subbands causes information loss in the respective sub bands. That is why SWT is employed to minimize this loss. The Stationary wavelet transform (SWT) is a Wavelet Transform algorithm designed to overcome the lack of translation invariance of the Discrete Wavelet Transform (DWT).

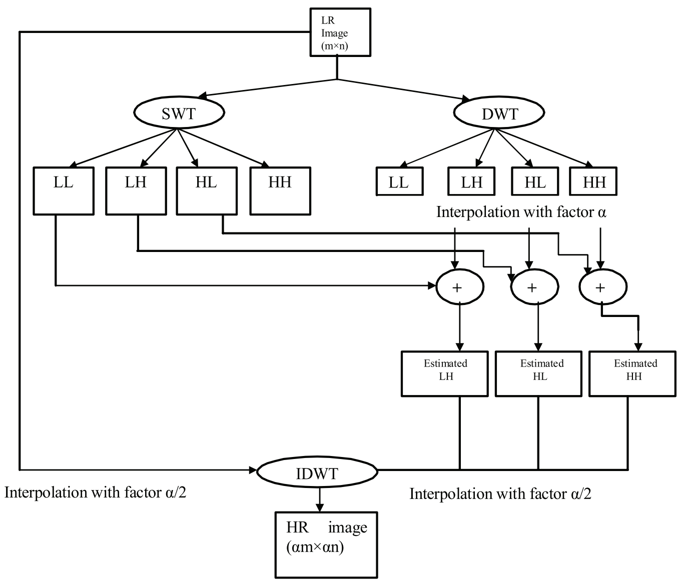

Fig.1 Block Diagram of proposed super resolution Algorithm

Translation-invariance is achieved by removing the down samplers and up samplers in the DWT and up sampling the filter coefficients by a factor of $2(j - 1)$ in the jth level of the algorithm. The SWT is an inherently redundant scheme as the output of each level of SWT contains the same number of samples as the input - so for a decomposition of N levels there is a redundancy of N in the wavelet coefficients. The interpolated high frequency sub bands and the SWT high frequency sub bands have the same size which means they can be added with each other. The new corrected high frequency sub bands can be interpolated further for higher enlargement. Also it is known that in the wavelet domain, the low resolution image is obtained by low pass filtering of the high resolution image [16]. In other words, low frequency sub band is the low resolution of the original image. Therefore, instead of using low frequency sub band, which contains less information than the original high resolution image, we are using the input image for the interpolation of low frequency subband image. Using input image instead of low frequency subband increases the quality of the super resolved image. Fig.1 illustrates the block diagram of the proposed image resolution enhancement technique. By interpolating input image by α/2, and high frequency subbands by 2 and α in the intermediate and final interpolation stages respectively, and then by applying IDWT.The output image will contain sharper edges than the interpolated image obtained by interpolation of the input image directly. This is due to the fact that, the interpolation of isolated high frequency components in high frequency subbands and using the corrections obtained by adding high frequency subbands of SWT of the input image, will preserve more high frequency components after the interpolation than interpolating input image directly.

III. Image Resolution Enhancement By Using Interpolation

Image super resolution Enhancemen Algorithm: Enhancement algorithm improves the clarity images. Following steps constitute the enhancement algorithm.Fig 2. illustrates the steps of the proposed super resolution algorithm.

A) Preprocessing

In signal processing, it is often desirable to be able to perform some kind of noise reduction on an image or signal. The median filter is a nonlinear digital filtering technique, often used to remove noise

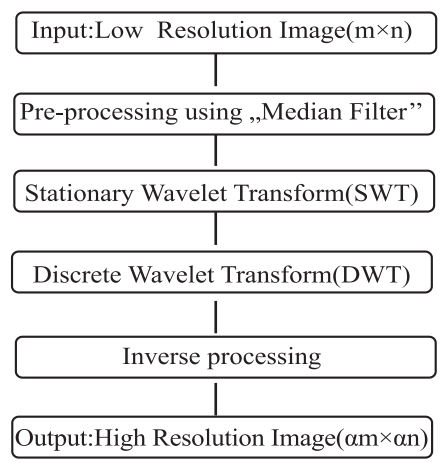

Fig. 2-Steps in MATLAB Implementation

Such noise reduction is a typical pre-processing step to improve the results of later processing (for example, edge detection on an image). Median filtering is very widely used in digital image processing because, under certain conditions.In this process we use Median Filter,Because it preserves edges while removing noise and enhance the pixel using sharpening method.

B) Stationary Wavelet Transform

The Stationary wavelet transform (SWT) is a wavelet transform algorithm.

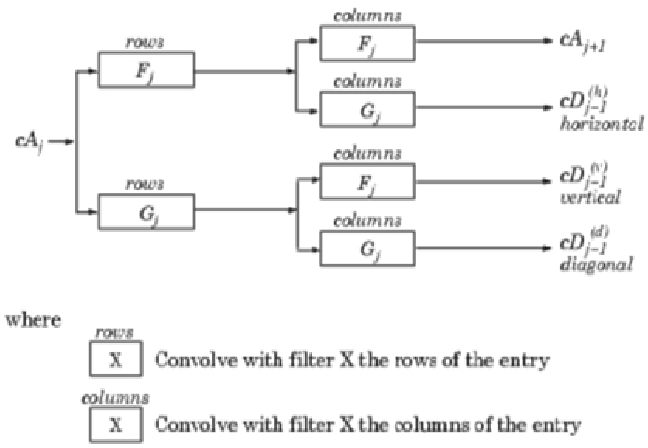

Fig.3 2D Stationary Wavelet Transform

Fig 3. illustrates the process of SWT.Translation-invariance is achieved by removing the down samplers and up samplers in the DWT and up sampling the filter coefficients by a factor of 2(j − 1) in the jth level of the algorithm. The SWT is an inherently redundant scheme as the output of each level of SWT contains the same number of samples as the input , so for a decomposition of N levels there is a redundancy of N in the wavelet coefficients.

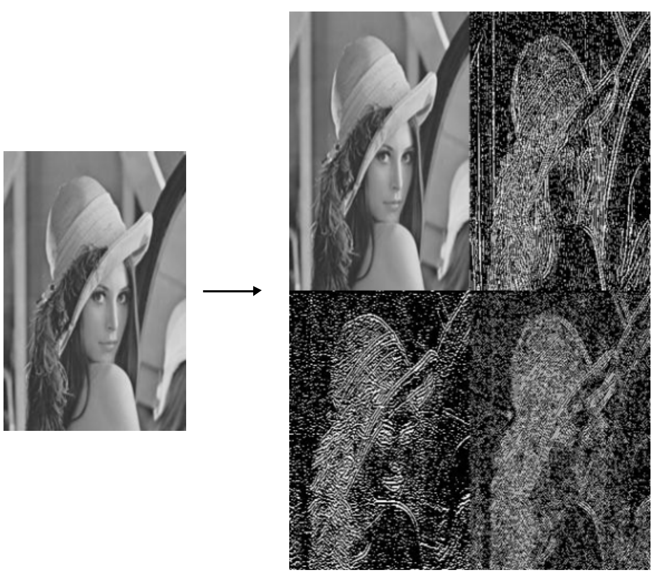

Fig. 4 Test Image is decomposed by SWT into four subbands.

C) Discrete Wavelet Transform

The DWT has received considerable attention in various signal processing applications, including image watermarking. The main idea behind DWT results from multiresolution analysis, which involves decomposition of an image in frequency channels of constant bandwidth on a logarithmic scale. It has advantages such as similarity of data structure with respect to the resolution and available decomposition at any level.

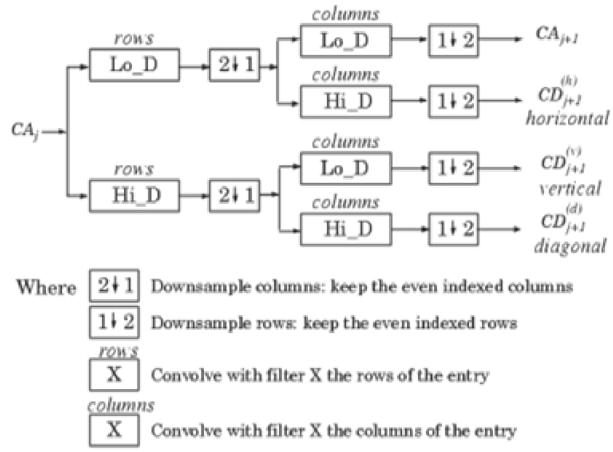

Fig.5 2D Discrete Wavelet Transform

Fig 5. illustrates the process of DWT.The DWT can be implemented as a multistage transformation. An image is decomposed into four subbands denoted LL, LH, HL, and HH at level 1 in the DWT domain, where LH, HL, and HH represent the finest scale wavelet coefficients and LL stands for the coarse-level coefficients.

Fig. 6 Test Image is decomposed by DWT into four subbands

D) Inversing Process

Finally, corrected interpolated high frequency subbands and interpolated input image are combined by using inverse DWT (IDWT) to achieve a high resolution output image.

IV.Simulation Results And Discussions

In this section, we compare the performance of the proposed scheme with conventional and state-of-art resolution enhancement techniques: bilinear, bicubic, WZP, NEDI, HMM, HMM SR, WZP-CS, WZP-CS-ER, DWT SR, CWT SR, and regularity-preserving image interpolation.

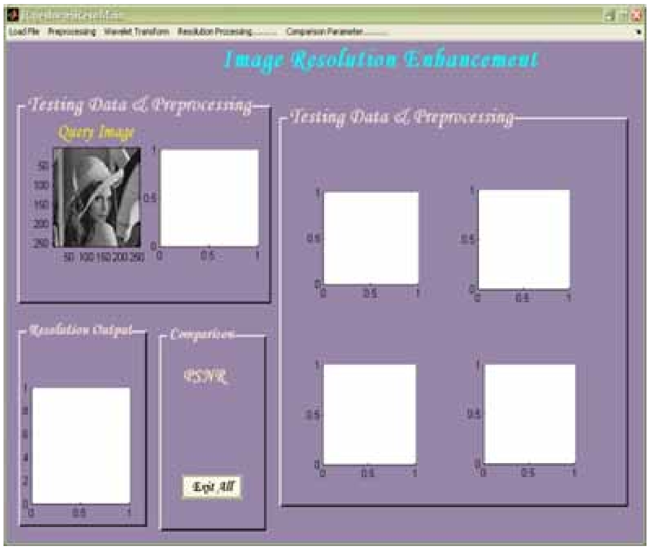

Fig. 7 Load Image process

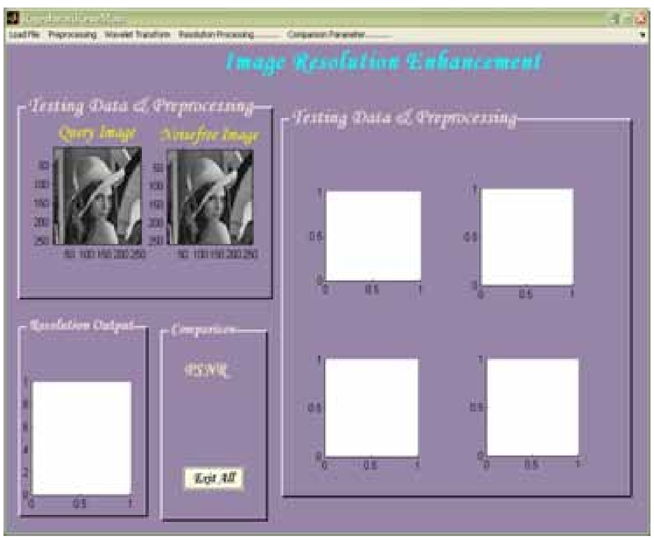

Fig. 8 Preprocessing using Median Filter

Fig. 9 Stationary Wavelet Transform

Fig.10 Discrete Wavelet Transform

Fig.11 Inverse Processing

V. Conclusion

This work proposed an image resolution enhancement technique based on the interpolation of the high frequency subbands obtained by DWT, correcting the high frequency subband estimation by using SWT high frequency subbands, and the input image. The proposed technique uses DWT to decompose an image into different subbands, and then the high frequency subband images have been interpolated. The interpolated high frequency subband coefficients have been corrected by using the high frequency subbands achieved by SWT of the input image. An original image is interpolated with half of the interpolation factor used for interpolation the high frequency subbands. Afterwards all these images have been combined using IDWT to generate a super resolved imaged. The proposed technique has been tested on well-known benchmark images, where their PSNR and visual results show the superiority of proposed technique over the conventional and state-of-art image resolution enhancement techniques.

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