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A Robust Image Enhancement by Using Multi-Resolution Transforms

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Abstract: *In this paper presents a regularized image interpolation algorithm, an image resolution enhancement technique based on interpolation of the high frequency sub-band images obtained by using one of the multi resolution algorithm discrete wavelet transform (DWT) and the input image. Edges in images convey a great deal of information, but wavelet transforms do not provide an economical representation. Thus, popular wavelet-based decomposition and restoration techniques perform poorly in the presence of edges. The edges are enhanced by introducing an intermediate stage by using stationary wavelet transform (SWT) which is the one of the Multi-Resolution Transforms (MRT). 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 and are being modified by using high frequency sub-band obtained through SWT. Then high frequency and low frequency of these sub-bands are combined to generate a new high resolution image by using inverse DWT (IDWT). The quantitative and visual information results are showing the Enhancement of the edges of an input image robustly by introducing an intermediate stage by using Multi-Resolution Transforms (MRT)*

Keywords: *Image interpolation, Image super resolution, Multi-Resolution Transforms (MRT),Robustness.*

I. INTRODUCTION

Image enhancement plays key role in digital processing so we focus on the importance of the representation of information for various image processing tasks. The way in which manipulation of information is represented brings out certain types of features while hiding others. Signal compression and estimation applications also rely heavily on having an efficient representation of image data; we would like to approximate a signal with a few number of parameters. Therefore, we seek a transform which yields an efficient representation while bringing out the desired features of the signal [1]. Resolution has been frequently referred as an important aspect of an image. Images are being processed in order to obtain more enhanced resolution. Interpolation is One of the commonly used technique for image resolution enhancement. It has been widely used in many applications in image processing such as facial reconstruction, multiple description coding, and super resolution. Interpolation is the process of using known data values to estimate unknown data values. Various interpolation techniques are often used in this project. Interpolation as used here is different to "smoothing", the techniques discussed here have the characteristic that the estimated curve passes through all the given points. The idea is that the points are in some sense correct and lie on an underlying but unknown curve, the problem is to be able to estimate the values of the curve at any position between the known points[2-3]. The methods Nearest neighbor interpolation, Bilinear interpolation, and Bi-cubic interpolation are three well known interpolation techniques. Bilinear interpolation is an extension of linear interpolation for interpolating functions of two variables.

Bicubic interpolation is an extension of cubic interpolation for interpolating data points on a two dimensional regular grid. The interpolated surface is smoother than corresponding surfaces obtained by bilinear interpolation or nearest-neighbor interpolation. Bicubic interpolation can be accomplished using either Lagrange polynomials, cubic splines, or cubic convolution algorithm [4].

In this correspondence we mainly deal with image interpolation techniques to enhance the image quality in the basis of resolution. In image processing the terminology "resolution" represents the number of pixels in an image, which determines the physical size of the image, and at the same time it also represents the fidelity to high-frequency details in the image. By this reason, resolution is a fundamental issue in evaluating the quality of various image processing systems. Image interpolation is used to derive a higher resolution image from a low resolution image, and therefore it is most important in multi-resolution or high-resolution image processing. For example, the spatial scalability function in MPEG-2 and wavelet-based image processing techniques require image interpolation techniques [5]. On the other hand, high-resolution image processing applications such as digital High Definition Tele-Vision (HDTV),aerial photos, medical imaging such as scanning, and military purpose images, need high-resolution image interpolation algorithms. Recently, it can also be used in changing the format of various types of images and videos, and in increasing the resolution of images.

Image resolution can be measured in various ways. Basically, resolution quantifies how close lines can be to each other and still be visibly resolved. The measure of how closely lines can be resolved in an image is called spatial resolution, and it depends on properties of the system creating the image [6].

Image resolution enhancement in the wavelet domain is a relatively new research topic and recently many new algorithms have been proposed. Discrete wavelet transform (DWT) is one of the recent wavelet transforms used in image processing. DWT decomposes an image into different sub-band images, namely low-low (LL), low high (LH), high-low (HL), and high-high (HH). Another recent wavelet transform which has been used in several image processing applications is stationary wavelet transform (SWT). In short, DWT is similar to SWT, used in down-sampling, hence the sub-bands will have the same size as the input image.

In this paper, we are proposing a robust image enhancement technique which generates sharper high resolution image. The proposed technique uses DWT as well as SWT ,DWT uses to decompose a low resolution image into different sub bands. Then the details have been interpolated using bicubic interpolation. The details obtained by SWT of the input image are being incremented into the interpolated high frequency subbands in order to correct the estimated coefficients. In parallel, the input image is also interpolated separately. Finally, corrected interpolated high frequency subbands 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 enhancement techniques. The conventional techniques used are the following: Interpolation techniques.

→Bilinear interpolation and
→Bicubic interpolation.
→Wavelet zero padding (WZP).
→Super resolved interpolated technique

According to the quantitative and qualitative experimental results, the proposed technique over performs the aforementioned conventional for image resolution enhancement.

II. IMAGE RESOLUTION ENHANCEMENT

Quality in Digital Imagery obtained by enhancement (wanted e.g. for visual inspection or for machine analysis), there is no knowledge about the source of degradation. If the source of degradation is known, one calls the process image restoration. Both are iconical processes, viz. input and outputs are images. Many different, often elementary methods are used to improve images in some Part. The problem is, of course, not well defined, as there is no objective improve for image quality. Here, we discuss a few recipes that have shown to be useful both for the human observer and/or for machine recognition. These methods are very problem-oriented: a method that works fine in one case may be completely inadequate for another problem.

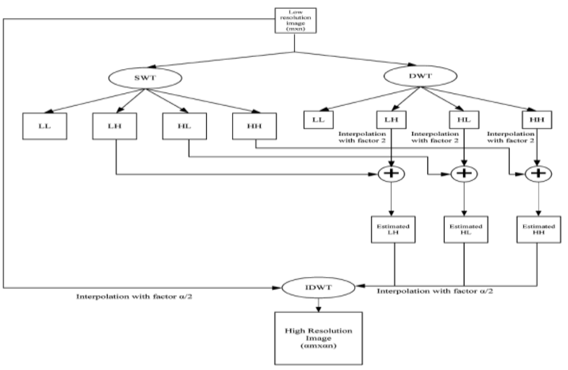


Figure 1: Block diagram of the super resolved interpolation algorithm.

By using interpolation we can enhance image for this we have to concentrate on its high frequency aspects (i.e.,edges),that is smoothing caused by interpolation .To increase the quality of the super resolved image we must preserve the edges. For this work, DWT has been used to protect the high frequency sub-bands of the image .DWT coefficients are inherently interpolable that means it is redundancy and shift invariance[7]- [9].

In this work, we are using one level DWT (with Daubechies 9/7 as wavelet function) to decompose an input image into different sub-band images like approximations and details means three high frequency sub-bands like LH, HL, and HH contain the high frequency components of the input image and LL contain the Low frequency components of the input image[10]. In the super resolved interpolation technique, bicubic interpolation with enlargement factor of 2 is applied to high frequency sub-band images. Down sampling in each of the DWT sub-bands causes information loss in the respective sub-bands. That is why SWT is employed to minimize this loss.

The SWT high frequency sub-bands and the interpolated high frequency sub-bands have the same size because here we are not using down sampling so that they can be added with each other. For the further higher enlargement the new corrected high frequency sub-bands can be interpolated. Also it is known that in the wavelet domain, the low resolution image is obtained by low-pass filtering of the high resolution image. In other words, low resolution of the original image means image consists of low frequency sub-band. 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 sub-band image. Using input image instead of low frequency sub-band increases the quality of the super resolved image. Fig. 1 illustrates the block diagram of the super resolved image interpolation enhancement technique[11].

By interpolating input image by α/2, and high frequency sub-bands in DWT by 2 and added to high frequency bands to obtain estimated high frequency bands, α in the intermediate and final interpolation stages respectively, and then by applying IDWT, as illustrated in Fig. 1, 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 sub-bands and using the corrections obtained by adding high frequency sub-bands of SWT of the input image, will preserve more high frequency components after the interpolation than interpolating input image directly.

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 sub-bands. Then the three high frequency sub-band images have been interpolated using bi-cubic interpolation with factor 2. The Low frequency sub-bands obtained by SWT of the input image are being interpolated bicubic with factor 2 and subtracts original image gets difference image, added to bicubic interpolated high frequency 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 enhancement techniques [12]-[15]. We propose a Multi 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[16].

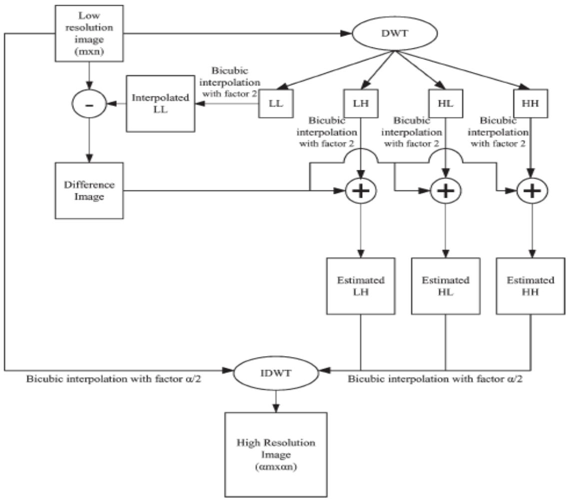


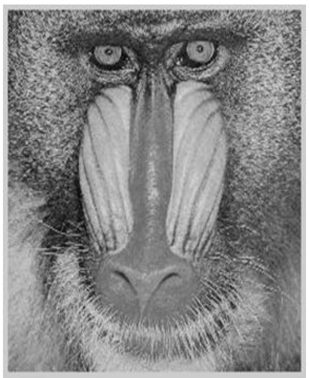
Figure 2: Block diagram of the proposed algorithm

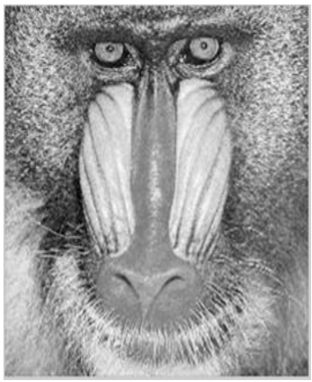
The proposed technique has been compared with standard interpolation techniques, wavelet zero padding (WZP),super resolved bicubic interpolated where the unknown coefficients in high-frequency sub bands are replaced with zeros,.

In all steps of the proposed satellite image resolution enhancement technique, Daubechies wavelet transform as mother wavelet function and bicubic interpolation as interpolation technique have been used.

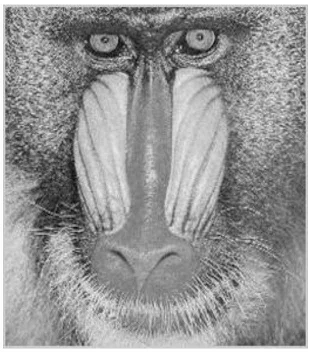
III. RESULTS AND DISCUSSIONS

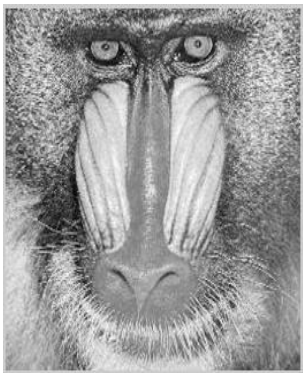
The Super resolved image of Baboon's picture using proposed technique is shown Fig. 3 the image in (f) are much better than the low resolution image in (a), Bilinear interpolated image (b), Bicubic image (c) ,Super resolved image using WZP (d) and super resolved image by using the interpolation (e) . Note that the input low resolution images have been obtained by down-sampling the original high resolution images. In order to show the effectiveness of the proposed method over the conventional resolution enhancement techniques, four well-known test images such as Lena, Elaine, Baboon, and Peppers etc., with different features are used for comparison[17]. Table I compares the PSNR performance of the proposed technique using bicubic interpolation with conventional and state-of-art resolution enhancement techniques: bilinear, bicubic, Super resolved image using WZP, and Super resolved image using bilinear interpolation preserving image interpolation. Additionally, in order to have more comprehensive comparison, the performance of the super resolved image by using SWT only (SWT-SR) is also included in the table. The results in Table I indicate that the proposed technique over-performs the aforementioned conventional and state-of-art image resolution enhancement techniques. Table I also indicates that the proposed technique over-performs the aforementioned conventional image resolution enhancement techniques.


(a)


(b)


(c)


(d)


(e)

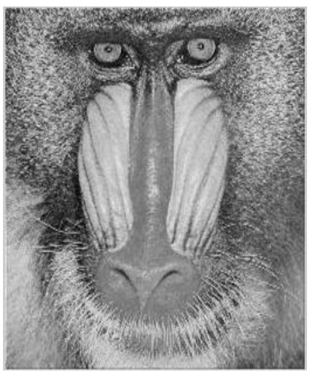

(f)

Fig.3 (a) Original low resolution Baboon's image. (b) Bilinear interpolated image (c) Bicubic interpolated image. (d) Super resolved image using WZP. (e) Super resolved image using bilinear interpolation (f) Proposed technique.

IV. CONCLUSION

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 image resolution enhancement techniques. The image resolution enhancement technique based on the interpolation of the high frequency sub-bands obtained by DWT, correcting the high frequency sub-band estimation by using SWT high frequency sub-bands, and the input image. The proposed technique uses DWT to decompose an image into different sub-bands, and then the high frequency sub-band images have been interpolated. The interpolated high frequency sub-band coefficients have been corrected by using the high frequency sub-bands achieved by SWT of the input image. An original image is interpolated with half of the interpolation factor used for interpolation the high frequency sub-bands. Afterwards all these images have been combined using IDWT to generate a super resolved imaged. Here we are using interpolation to gets the robustness. 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.

TABLE I

Techniques\Images	**Baboon**	**Lena**	**Barbara**
Bilinear	27.7120	29.2821	28.0735
Bicubic	29.6867	31.3053	30.1179
WZP	34.8653	36.4802	35.4011
Super resolved interpolated technique	35.0445	36.8774	35.7141
Proposed Technique	**35.5102**	**37.1994**	**36.0071**

PSNR (DB) RESULTS FOR RESOLUTION ENHANCEMENT FROM 128×128 TO 512×512 OF THE PROPOSED TECHNIQUE COMPARED WITH THE CONVENTIONAL AND STATE-OF-ART IMAGE RESOLUTION ENHANCEMENT TECHNIQUES

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