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Enhancement of Low Resolution Images Using Wavelet Transform

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ABSTRACT

The aim of image resolution enhancement is to process of low image resolution to make higher resolution image for specific application. In the work, we have proposed an image resolution enhancement technique that generates sharper and high resolution output image. Decomposing low resolution image in different sub-bands is used proposed technique. After that three higher frequency band images are interpolated by using bi-cubic interpolation. This higher frequency bands produced by stationary wavelet transform of the given input image are then increased into the interpolated higher frequency bands in order to correct the coefficients. The given input image is interpolated in parallel. Super resolved image is generated by combining using Inverse DWT.

Keywords- Image resolution enhancement, Interpolation, Inverse discrete wavelet transform, Discrete wavelet transform, Stationary wavelet transform.

I. INTRODUCTION

Out of all five senses vision is most advanced, so it is not surprised that images play the single most important role in human perception. Human vision is limited to visual band of electromagnetic (EM) spectrum, while imaging machines cover almost the entire EM spectrum, ranging from gamma to radio waves. They can work on images created by source that humans are not customary to associate with images. These include electron microscopy, computerize images. Digital image processing works same way as the human vision system. It involves the process of acquiring, analyzing and manipulating images using digital computers. There are various physical devices to capture digital images like camera, satellite, magnetic resonance imaging machine and microscope etc. The area of application of digital image processing is very vast. With increase in demand and performance of personal computing digital image processing is widely being used in many applications. Digital image process has advantage in term of cost, speed and flexibility. The objective is to bring out information from the scene being viewed. Digital image processing can be classified in following subareas on the basis of nature of application. Image Enhancement Image Restoration Image Compression Image Segmentation Image .

IJARSE
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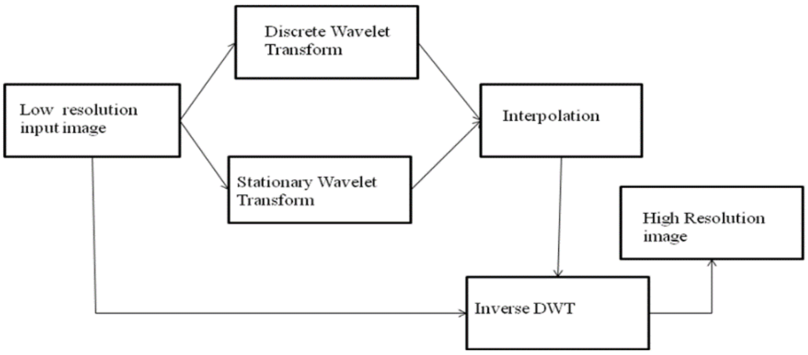

Fig.1 Block Diagram of Image Resolution enhancement Technique [27]

Understanding A digital can be represented by function of two dimensional variables and mathematically can be represented as I = f(x, y) (1) here I is an image, x and y are spatial coordinates, and f is the amplitude of any pair of coordinates (x, y) and is called as intensity or grey level of the image at that point. When values of coordinates (x,y) and amplitude f all are finite and discrete quantities, the image is called digital image. There are various image processing application requires high resolution images for processing and analysis. The desire for high resolution images came from two principal application areas: improvement of pictorial information for human elucidation; and helping representation for automatic machine perception. Image resolution describes the amount of information contained by images. Lower resolution less would be the amount of information, higher resolution more would be amount of considered. Resolution of a digital image can be classified in many ways: pixel resolution, spatial resolution, spectral resolution, temporal resolution, and radiometric resolution.[1] A digital image is made from small picture elements called pixels. Spatial resolution mentions the pixel density in an image and measures in pixels per unit area. Resolution has been often referred as an important aspect of an image. Images are being processed in order to obtain more improved resolution. One of the commonly used techniques for image resolution enhancement is Interpolation. Three interpolation techniques are nearest neighbor interpolation, bilinear interpolation, and bi-cubic interpolation. 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). SWT is similar to DWT but it does not use down-sampling, therefore the sub-band have the same size as the input image. Proposed image resolution technique used to generate sharp high resolution image. The proposed technique utilizes DWT to decompose a low resolution image into different sub-bands. Then the three high frequency subband images are then interpolated using bi-cubic interpolation. The high frequency sub-bands which are obtained by SWT of the input image are being incremented into the interpolated high frequency sub-bands in order to correct the calculated coefficients. In parallel, the input image is interpolated separately. Finally, improved interpolated high frequency sub-bands and interpolated input image are combined using inverse DWT (IDWT) to get a high resolution output image. The conventional techniques used are the following. Bilinear interpolation Bi-cubic interpolation. Wavelet zero padding (WZP). According to the quantitative and qualitative experimental results, the proposed technique well over performs the abovementioned conventional and state-of-art techniques for image resolution enhancement.

II. LITERATURE SURVEY

In order to start the thesis, the first step is to study the previous work performed by researchers. For this purpose various papers have been studied. Below are the literature review in image enhancement by some authors and their main observations:

A. Regularity-preserving image interpolation

Author estimated the regularity of edges by measuring the decay of wavelet transform coefficients across scales and restores the underlying regularity by extrapolating a new sub-band to be used in image re-synthesis. The algorithm produces visibly sharp edges than traditional techniques and gives an average peak signal-to-noise ratio (PSNR) improvement of 2.5 dB over bilinear and bicubic techniques. By W.K. Carley, D.B. Chuang and S.S.Hemami.

B. Optimal image scaling using pixel classification

Author introduced a new approach to optimal image scaling called resolution synthesis (RS). In RS, the pixel interpolated is first classified in the context of a window of neighboring pixels; and the corresponding high resolution pixels are obtained by filtering with coefficients that depend upon the classification. By C.B. Atkins, C.A. Bouman and J.P. Allebach. Shape-adaptive coding using binary set splitting with k-d trees: An embedded wavelet image coder based on the popular bitplanecoding paradigm, BISK is designed specifically for the coding of image objects with arbitrary shapes. Empirical results indicate that the proposed BISK coder consistently gives efficient performance when compared to a variety of other shape-adaptive coders. By J.E. Fowler. Image resolution enhancement utilizing inter-sub-band correlation in wavelet domain: In this paper, author proposed a new resolution enhancement method utilizing inter-sub-band correlation in which the sampling phase in DWT in the higher level. By Y. Piao, I.Shin and H.W. Park. The wrinkle generation method for facial reconstruction based on extraction of partition wrinkle line characterizes and patterns interpolation: Because of the high putrescibility of the body, in general condition only part of bones can be found when the victim body was discovered. Therefore, in the first step of the criminal investigation is to reconstruct the facial characteristics in order to find the victim. Because wrinkle is the most remarkable and intuitionistic characteristics in the human skin, the wrinkle generation method for reconstructed face is an important step of facial reconstruction. By L.Yi-bo, X.Hong and Z.Senyue. Downsample-based multiple description coding and post-processing of decoding: This work proposed an image resolution enhancement technique which is build on the interpolation of high frequency sub-bands obtained by DWT. This proposed technique utilizes DWT to decompose an low resolution image into different sub-bands, and then the high frequency sub-band images are interpolated. By H. Demirel and G.Anbarjafari. Image resolution enhancement by utilizing discrete and stationary wavelet decomposition: In this correspondence the authors proposes an image resolution enhancement technique build on interpolation of the high frequency sub-band images obtained by DWT and the input image. SWT is utilized for enhancement of edges of images where SWT is immediate stage. DWT is utilized to decompose input image into different sub bands. Then the high frequency sub-bands as well as the input image are interpolated. By A.Bouman.

IJARSE
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III. SYSTEM IMPLEMENTATION

Image resolution enhancement in the wavelet domain is recently many new algorithms are proposed. Fig 2 shows structure of wavelet decomposition. Discrete wavelet transform i.e. DWT is most recent wavelet transforms used for image processing. DWT decomposes an original low resolution image into different sub-band images, namely low-low (LL), high-low (HL), low-high (LH), and high-high (HH) [27]. Stationary wavelet transform (SWT) has been used in many image processing applications. In short, SWT is similar to DWT but it does not use down-sampling. Fig 3 shows Structure of DWT decomposition while Fig. 4 shows Structure of SWT decomposition.

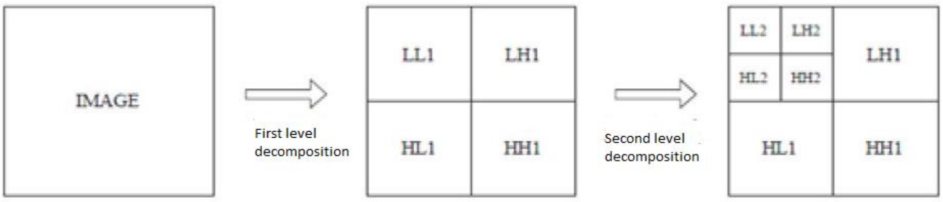

Fig.2 Structure of Wavelet Decomposition [27]

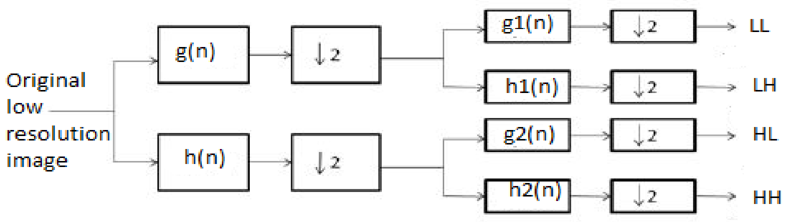

Fig.3 Structure of DWT Decomposition

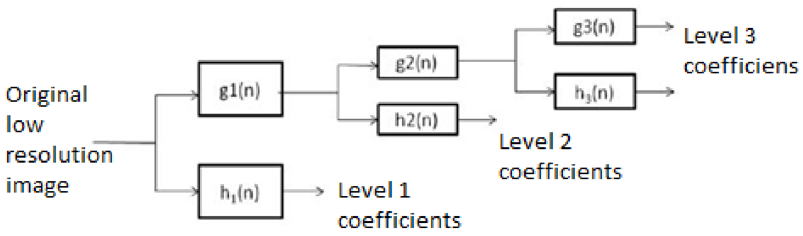

Fig.4 Structure of SWT Decomposition [27]

In this an image resolution enhancement technique is proposed which generates sharp high resolution image. In this technique low resolution image decomposes into different sub-bands by using DWT [27]. Then the three high frequency sub-band images are then interpolated. Then interpolation with enlargement factor of 2 is applied to high frequency sub band images. Down sampling in each step of the DWT sub-bands produces information loss in the respective sub-bands. That is why SWT is employed to minimize this loss. The interpolated high frequency sub bands and the SWT high frequency sub bands have the same size so that they can be added with each other. Interpolation of new corrected high frequency sub-bands has been done for higher enlargement. The lower frequency sub-band is low resolution of the original image. Therefore, instead of using low frequency sub band, which contains less information than the original high resolution image, the input

IJARSE
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image for the interpolation of low frequency sub band image is used. Fig. 5 is Block Diagram of Image Super resolution using wavelet analysis [1]. After all inverse DWT (IDWT) is used to get a high resolution output image by combining improved interpolated high frequency sub-bands and interpolated input image. The conventional techniques used for Interpolation are the following.

A. Bilinear Interpolation

Bilinear interpolation [28], [29] considers the closest 2x2 neighborhood of known pixel values surrounding the unknown pixel. It then takes a weighted average of these 4 pixels to arrive at its final interpolated value.

B. Bicubic Interpolation

Bicubic produces sharper than other two methods, and is the ideal combination of processing time and output quality. Bicubic [28] goes one step beyond bilinear by considering the closest 4x4 neighborhood of pixels for a total of 16 pixels. Since these are at various distances from the unknown pixel, closer pixels are given a higher weighting in the calculation.

C. Wavelet Zero Padding (WZP)

It is one of the methods for image resolution enhancement. It assumes that the signal is zero outside the original support. Accuracy of the reported amplitudes is improved in spectral analysis by using zero padding. Without using zero- padding, input frequencies will be attenuated in the output. The optimal interpolation in the frequency domain is equal to zero padding in time domain, which can restores the correct amplitudes. Shifting inter sample spacing in frequency of the array that represents the result by using zero padding technique.

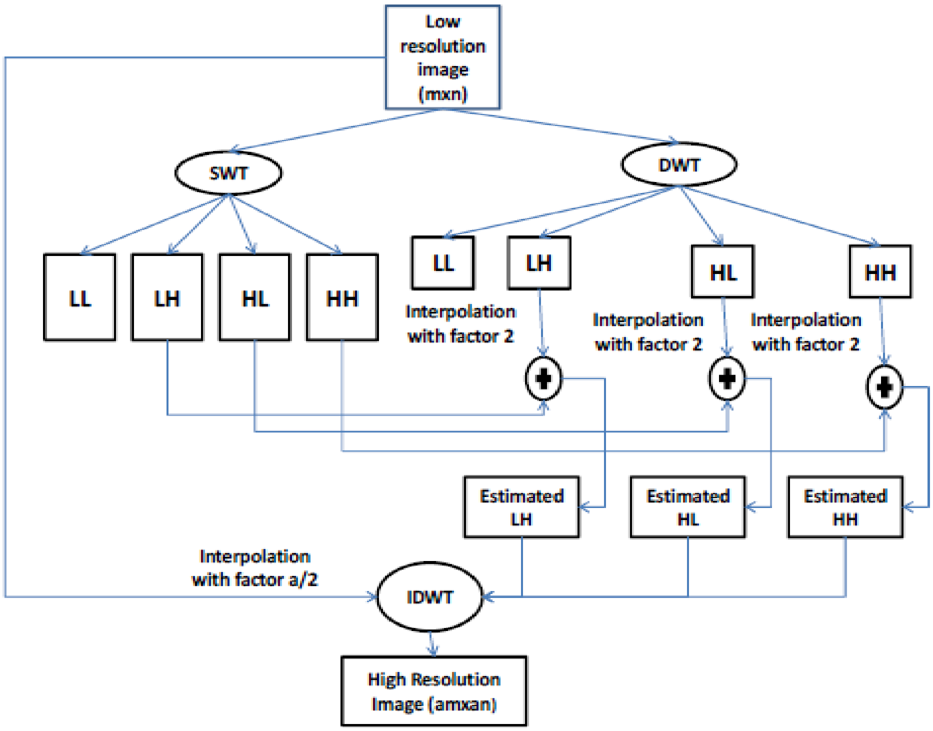

Fig.5 Detailed Block Diagram of Image Super resolution using wavelet analysis [1]

IJARSE
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IV. IMPLEMENTATION AND RESULTS

For the reason of measuring the performance characteristics of the techniques some parameters are used namely PSNR and MEAN.

Peak Signal to Noise Ratio

Peak signal-to-noise ratio i.e. PSNR is the ratio between the maximum possible power of a signal and the power of noise corrupted that affects the fidelity of its representation. Peak signal-to-noise ratio (PSNR) and mean square error (MSE) have been used in order to obtain some quantitative results for comparison. The MSE and PSNR are the two error metrics used to compare image compression quality. The lower the value of Mean square error, the lower the error.

PSNR can be obtained by using the following formula:

$$PSNR\ (dB) = 10 \log 10 \quad (255^2/MSE)$$

MSE is defined as,

MEAN

The Mean computes the mean of each row or column of the input, along with vectors of a specified dimension of the given input. The Mean block can also track the value of mean in a sequence of inputs over a period of time. Select the Running mean check box for track the mean value in a sequence of inputs. When the Running mean check box is not selected then the block computes the mean value in each row or column of the input, along vectors of a specified dimension of the given input, or of the entire input at each individual sample time. Each element in the output array is the mean value of the corresponding column, row, vector, or entire input.

The low resolution image is enhanced by using the bilinear interpolation, bicubic interpolation, WZP and proposed Image Resolution enhancement Technique. These techniques are tested on iris image dataset from Computer Vision Laboratory, Department of Automation and Computer-aided Engineering, The Chinese University of Hong Kong. Table 1 compares the parameters i.e. PSNR AND Mean of the different techniques i.e. bilinear, bi-cubic, WZP.

Table1: Result of PSNR and MEAN using Different techniques.

Image Resolution Technique	PSNR	MEAN
Bilinear	29.37	0.85
Bi-cubic	31.40	0.002
WZP	37.28	0.19
Proposed	37.32	0.19

(a) **(b)** **(c)**

IJARSE
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(d) (e)

Fig.6:- (a) Original image of Sara (b) Bi-cubic Interpolated image (c) Bilinear Interpolated image (d) Wavelet zero padding image (e) Proposed technique image

V. CONCLUSION

The proposed image enhancement technique is 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. In this proposed technique DWT is used to decompose an image into different sub bands, and then the high frequency sub band images have been interpolated. IDWT to generate a super resolved image by combining. The proposed technique has been tested on well-known benchmark images in which their PSNR and visual results show the performance of proposed technique over the conventional and state-of-art image resolution enhancement techniques.

A. Advantages

1. Proposed method of image enhancement is used to enhance the images by using different interpolation techniques-Bilinear,Bicubic,WZP.
2. The image enhancement based on SWT and DWT transform is the most important technique of image enhancement.
3. for image enhancement, multiscale wavelet decomposition is greatly effective.
4. Allows good localization both in time domain and frequency domain.
5. Reduces computation time
6. Reduces resource requirement
7. Multiresolution analysis.
8. DWT can be implemented in hardware.
9. Perform well in high compression ratio.

B. Applications

1.Medical Imaging
2. Forensic Science
3. Remote Sensing
4. Surveillance
5. Child base Detection

IJARSE
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6. Homeland Defence
7. Access Control
8. Financial Services
9. Immigration

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