Enhancement of Image Resolution Using Discrete Wavelet Analysis.

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ABSTRACT

Image Enhancement is an important aspect in the field of Biomedical such as diagnosis of diseases, CT scan, MRI, chromosome images etc. Now a day's it is also helpful in enhancement of satellite images for identification of terrestrial zone, enemy attack and locating natural resources etc. Here have proposed algorithm based on Discrete and Stationary wavelet analysis for image resolution & enhancement with the help of input low resolution image. This algorithm accentuates or sharpens image features such as edges, Cut part of image boundaries & color contrast for analysis. By using Discrete Wavelet Transform (DWT) decomposition take place into different sub-bands, which divides a low resolution image into different distinct sub-bands. The three higher frequency components of an image among the four frequency sub-bands have been interpolated using bi-cubic interpolation. The high resolution image can be estimated by combining the higher three frequency components of stationary wavelet band and bi-cubic interpolation. After a estimation combination of high frequency sub bands & original low resolution image occurs with the help of inverse DWT (IDWT). PSNR is used as quality measure to compare the proposed method with other methods. The quantitative and qualitative result of obtained for PSNR shows the superiority of proposed method over the state of art techniques like bi-linear interpolation, Bi-cubic interpolation, Wavelet zero padding.

Keywords — Bi-cubic interpolation, Discrete wavelet transform (DWT), PSNR, Stationary wavelet transform (SWT), Wavelet zero padding(WZP).

INTRODUCTION

In today’s smart world image, video, signal etc. are the important area for communication, analysis as well as information, Among from this image is an important an vital application for analysis and information. Therefore to achieve image augmentation is a search and research area of many application such as geostationary images, Medical image analysis, Real time images, standard computer data base images, surveillance and video enhancement as well as image feature extraction. Now a day's Image enhancement is challenge for today's technology in the field of satellite image enhancement applications which include mine detec-
tion, urban planning, military planning, intelligence and disaster monitoring and evaluation. There are many image resolution enhancement techniques proposed by many researchers in last decades such as,
- New edge directed interpolation[5];
- Interpolation by using bi-linear and nearest interpolation[7];
- Hidden Markov model[12];
- HMT-based image super resolution [6]
- WZP and cycle-spinning[4];
- DWT based super resolution[13];
- Image Resolution Enhancement Using Complex Wavelet Transform (CWT)[2];
- Image Resolution Enhancement using Inter-Subband Correlation in Wavelet Domain[11];
- Optical image scaling using pixel classification[14];
- Discrete Wavelet Transform-Based Satellite Image Resolution Enhancement [3]

Image Enhancement Using Various Interpolation Methods[8] gives various techniques of image enhancement by using interpolation such as nearest neighbor interpolation, Bi-linear interpolation, Bi-cubic interpolation[8]. But interpolation fails to preserve the high frequency component of low resolution images which contain the information of edges[8-9].

In the research of Temizel and Vlachos [4] give idea regarding wavelet zero padding[4] with initial approximation to the unknown high resolution image generated from wavelet domain zero padding combine with low resolution image. From this approach they introduced WZP method, cycle spinning method is used to remove the ringing artefacts and increasing the perceptual quality of image[4].

In the search of discrete wavelet transform-based on satellite image resolution enhancement[3] based on the principle decomposition of image by using DWT then take the interpolation of higher frequencies of DWT followed by IDWT with input low resolution image. However it can achieve better PSNR and sharpness of an image. The size of image is also changes.

Naman and Vijayan [10] work based on Undecimated Wavelet Transformation(UWT) where low resolution image consider as approximation part of low frequency of an unknown wavelet transform of high resolution image. The higher frequency detail coefficients are estimated using the UWT to obtain the unknown high resolution image[10].

Demirel and Anbarjafari [2] explored dual tree complex wavelet transform(DT-CWT) where image is split into two complex valued low frequency sub band images and six complex valued high frequency images using direction selective filters[2]. Then obtained images are interpolated followed by using IDT-CWT to combine all images to produce resolution enhanced image.

The objective all these techniques satisfies some image enhancement parameters but they have their own limitations when used for various database. Mostly consist of values of PSNR, MSE, Entropy,SSIM, Computational time, low contrast and low sharpness. In this paper, we have proposed a advanced image en-
hancement technique by using Discrete Wavelet Transform (DWT) db7 level of decomposition and Stationary Wavelet Transform (SWT) for image enhancement in conjunction with bi-cubic interpolation.

This paper is organized in such way that Section II describes about proposed technique with DWT, SWT, Bi-cubic interpolation. Proposed algorithm represented in same section The experimental results with database are presented in section III and finally conclusion is drawn on the basis of those results in Section IV.

PROPOSED ALGORITHM

The proposed algorithm uses combination of DWT and SWT in conjunction with bi-cubic interpolation for the image resolution enhancement. The DWT and SWT are preferred for image enhancement because of their superior operation in the interpolation of images. The DWT preserves high frequency components which consist of information about the edges.

The input to the system is a low resolution image from satellite database, medical image or real time database. The input image is converted into gray scale format to avoid large computation time, large computing cost and memory requirement. The gray scale image is decomposed into different sub-bands by using Discrete Wavelet Transform (DWT). System analysis of proposed algorithm consists of,

Image Decomposition by using DWT

The DWT is a discretely sampled version of wavelet transform. It represents the digital signal on time-scale and time-shift scale. In case of DWT the scale and shift parameters are discretized as, \(a = a^m\) and \(b = nb\) Where equation of DWT as follows[15],

\[
F_{m,n}(t) = a^{-m/2} F\left(\frac{t-nb}{a^m}\right)
\]

Where m and n are the pixel integer value of an image. From above equation we can define the discrete wavelet transform in frequency domain as[15],

\[
S_{m,n} = \int_{-\infty}^{\infty} F_{m,n}(t) S(t) \, dt
\]

Where the function \(F_{m,n}(t)\) provides the sampling point on the scale-time plane. Apart from this linear sampling time on b-axis direction and logarithmic scale on a-axis direction.

In wavelet analysis, we often consider approximations and details. The approximations are the high-scale, low-frequency components of the signal. The details are the low-scale, high-frequency components. Depending upon resolution required DWT divides an image into different sub-band images, namely low-low frequency (LL), low-high frequency (LH), high-low frequency (HL), and high-high frequency (HH). The input image is decomposed or down sampled into sub bands by using series of successive low pass and high pass filters as shown in fig.1.
Decomposition by using DWT

From fig.1 we can see the signal 'S' passes through two complementary low pass and high pass filter to produced two signals 'A' and 'D'. Now signal 'A' is called approximation and signal 'D' is called details as mention earlier. The original signal consists of 1000 samples, after decomposition signal 'A' and 'D' consist of 500 sample each called as coefficient of approximation(cA) and coefficient of details(cD). Similarly we can perform number of decomposition level called as multilevel decomposition as shown in fig.2. It is also called as Wavelet decomposition tree[16-17].

Multiple decomposition level

The Discrete Wavelet Transform is divided in various families like Haar, Daubechies, Biorthogonal, Symlets etc. In our proposed algorithm we have used Daubechies db7 because of its number of advantages like simplicity and low computation time, memory efficient, etc. From the daubechies family db7 means wavelet function having 7 finite and vanishing point with respect to scale and shift[16-17].

Stationary Wavelet Transform

Stationary Wavelet Transform (SWT) is an un-decimated version of DWT. This transform algorithm is designed to overcome the lack of translation invariance in DWT. The main idea is to average several detailed co-efficient which are obtained by decomposition of the input signal without down sampling. This approach can be interpreted as a repeated application of the standard DWT method for different time shifts. SWT is similar to DWT except the input signal is never sub sampled and instead the filters are up sampled at each level of decomposition. This is indicated in fig.3. Therefore the sub-bands of SWT will have the same size as the input image which can be easily add with interpolated high frequency sub bands of DWT[16-17].
From SWT we can also enhance edge information. In the SWT signal is never sub sampled while filters are used to up sample at each level of decomposition.
Decomposition using SWT

Bi-cubic interpolation is advanced version from all other interpolation methods where we can take a weighted average of the 16 pixels to calculate it’s final interpolated value[9]. To find out the value nearer pixel consist of a higher weight while long distance pixel consist lower weight as shown in diagram[8-9]. From fig. 4 we can find the value of pixel (u,v) by using 16 nearer pixels. In proposed algorithm we can performed bi-cubic interpolation of DWT high frequency sub bands, Estimated out from SWT and DWT as well as original low resolution image as below.

Diagram of Bicubic Interpolation

In the first step, discrete wavelet transforms with Daubechies7 as the wavelet function and stationary wavelet transform are applied on the low resolution input image. In step two bi-cubic interpolations with enlargement factor of α/2 is applied to high frequency sub band images of the first step. In the third step we performed estimation of coefficient which are obtained by adding bi-cubic interpolation output and SWT higher frequency sub bands which having same size. In the fourth step, perform again bi-cubic interpolation of estimated output and original low resolution image as mentioned earlier. Finally, in step five we can take the inverse discrete wavelet transforms (IDWT) of original low resolution image and estimated output obtained from in-conjunction with SWT and DWT followed by bi-cubic interpolation as shown in flow alg-
rithm of proposed method. Fig.5 illustrates the block diagram of the proposed image resolution enhancement technique to obtained super enhanced image with sharp edges and reduced the invariance.

RESULTS AND DISCUSSION
The implemented algorithm is tested on different types of data such as satellite images, medical images, real time database images as well as standard MATLAB database. The below figures represents subjective analysis of an algorithm, In order to show the superiority of the proposed method over the conventional and state-of-art techniques from visual point of view. The mentioned figures are enhanced by using bi-linear interpolation, bi-cubic interpolation, Wavelet Zero Padding and also by the proposed technique. We can analyze enhancement of image by using result table mentioned in table 1 on the basis of PSNR value in decibel. We can also analyzed result on the basis of computational time and SSIM shown in table I.
Image Enhancement

(a) Bi-linear interpolation (b) Bi-cubic interpolation. (c) Wavelet Zero Padding (WZP) (d) By proposed algorithm of satellite images.

Fig. 5 shows the satellite image of a dam & tower, which clears the enhancement by using proposed method. It is more effective than bi-linear, bi-cubic as well as by using WZP technique.

![Image](a)

![Image](b)

![Image](c)

![Image](d)

Image Enhancement (a) Bi-linear interpolation (b) Bi-cubic interpolation. (c) Wavelet ZeroPadding (WZP) (d) By proposed algorithm of bio-medical images.

In fig. 6 we can see the typical application image enhancement of resolution to operate the problems of delicate part of human body as well as other bio-medical images.
Image Enhancement (a) Bi-linear interpolation (b) Bi-cubic interpolation. (c) Wavelet Zero Padding (WZP) (d) By proposed algorithm of real time database images.

Fig. 7 shows the result of moving object as a real time database, which also shows the better augmentation than conventional techniques.
Image Enhancement (a) Bi-linear interpolation (b) Bi-cubic interpolation. (c) Wavelet Zero Padding (WZP) (d) By proposed algorithm of standard computerized MATLAB database images.

In fig. 8 we take a standard image for proposed algorithm & observe the PSNR value. The above figures indicates that the edge, texture information, shape features are well preserved in the synthesized images of the proposed technique than the existing method. Moreover by using DWT and SWT in the proposed method, the enhanced images are free from noise effects. The PSNR value of the proposed technique is compared with conventional and state-of-art image resolution enhancement techniques and listed in Table1. The conventional techniques used for comparison are the interpolation techniques: bilinear interpolation and bi-cubic interpolation and Wavelet Zero Padding (WZP). It is clear that the resultant image, enhanced by using the proposed technique, is sharper than the other techniques.

Table-1 PSNR

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Name of Image</th>
<th>Bi-linear</th>
<th>Bi-cubic</th>
<th>WZP</th>
<th>Proposed technique</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Dam.jpg</td>
<td>29.54</td>
<td>31.54</td>
<td>36.14</td>
<td>36.8</td>
</tr>
<tr>
<td>2</td>
<td>Tower.jpg</td>
<td>28.78</td>
<td>30.82</td>
<td>35.57</td>
<td>36.08</td>
</tr>
<tr>
<td>3</td>
<td>Cell.jpg</td>
<td>27.49</td>
<td>29.49</td>
<td>34.57</td>
<td>34.85</td>
</tr>
<tr>
<td>4</td>
<td>Med.jpg</td>
<td>32.21</td>
<td>34.25</td>
<td>38.82</td>
<td>39.57</td>
</tr>
<tr>
<td>5</td>
<td>Plan.jpg</td>
<td>26.5</td>
<td>28.51</td>
<td>34.19</td>
<td>34.33</td>
</tr>
<tr>
<td>6</td>
<td>Rtdb.jpg</td>
<td>25.52</td>
<td>27.53</td>
<td>33.19</td>
<td>33.28</td>
</tr>
<tr>
<td>7</td>
<td>Lena.jpg</td>
<td>29.28</td>
<td>31.3</td>
<td>36.48</td>
<td>36.87</td>
</tr>
</tbody>
</table>

Fig.-1 Graphical representation of PSNR
CONCLUSION

This paper has proposed algorithm for image resolution enhancement technique based on combination of DWT & SWT over the interpolation & Wavelet Zero Padding techniques. It consists of the high-frequency sub band images obtained by DWT and the input image are interpolated to form high resolution image with better PSNR value as shown in table I. The proposed technique tested on satellite images, medical images, real moving images as well as standard database of well benchmark images for proper result. In stated algorithm PSNR and visual results shows the superiority of the proposed technique over the conventional and state-of-art image resolution enhancement techniques. The proposed technique uses DWT as decompose of an image into different sub band images, these obtained high frequency sub bands are interpolated by using bi-cubic algorithm. Correction & Estimation of high resolution image take place with the help of SWT & interpolation in normalization. The PSNR values of Table I show the efficiency & effectiveness of the proposed method over the other technique.

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