Resolution Enhancement of Satellite Images with Interpolation using DWT-SWT wavelet domain

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Abstract - Resolution of the image is very important aspect of the image. Resolution Of the image play very important role in satellite imaging also. In order to extract out important information from the image, an image with high resolution is needed. Due to the limitation of the satellite imaging it very costly to obtain the high resolution image. Various spatial domain and frequency domain based approach has been proposed in the past for enhancing the resolution of the image. Interpolation based approach and wavelet based approach of image resolution enhancement are widely used approach. Wavelet has very significant role in multi-resolution analysis.

Keywords— Discrete wavelet transform, interpolation, stationary wavelet transform, wavelet zero padding.

INTRODUCTION

Resolution is one of the important aspects of image or video which decides the clarity of the image or video. It is easier to extract out the detail information from the high resolution image or video. Satellite images are taken by the satellite which is equipped with very powerful camera. Satellite takes the snap of the earth from the distant place. These satellite images are then analyzed to see the detail information and analyze it. It is very important that before analyzing the satellite images, it resolution must be increased to extract out the detail information. Beside this resolution enhancement is also used in various image and video based processing such as Content based image retrieval, feature extraction, machine vision etc. In order to enhance the resolution of the image, number of pixel in an image need to be increased. Interpolation is one of this method which compute the pixel value in an image by considering the pixel around it and then insert it there. Image Processing operation can be divided in to two category i.e. Spatial domain techniques and frequency domain techniques. Spatial domain techniques directly operates on the pixel while the frequency domain techniques operates on the frequency domain version of the image or video. Interpolation has been used for enhancing the resolution of the image for years. Various interpolation methods has been introduced for enhancing the resolution of the image.

There are basically three interpolation method which are used most frequently i.e. Nearest neighborhood, Bi-liner and Bi-cubic. Among the three, bi-cubic interpolation technique is best in interpolating the most accurate missing pixel values. Though these techniques are easy but fail to give enhanced resolution image because being not able to produce high frequency part of the image. Recently, image resolution enhancement in frequency domain has emerged as a new research topic in this field. Different algorithm for image resolution enhancement has been proposed [8-11] . Discrete wavelet transform has been used in image processing for several years [8]. Discrete wavelet transform (DWT) divides the images in to different frequency sub-bands i.e. Low frequency band (LL), Mid Frequency Band (LH, HL) and high frequency band (HH).

Some of the common application of super resolution technique are as follows [4]-

i. Satellite Imaging
ii. Video enhancement and restoration.
iii. Confocal Microscopy.
iv. Astronomical imaging.
v. Video standard Conversion.
vi. Aperture Displacement Cameras.
vii. Diffraction Tomography.
viii. Video Freeze frame and hard copy.
ix. Restoration of MPEG-coded video stream.

As mentioned earlier that in various images processing application, High resolution image is necessity for accurate processing and analysis of the image. Two most common reasons for the requirement of the high resolution image are-

I. High resolution image has improved pictorial representation as compared to the low resolution image. Improved pictorial representation is require for human interpretation and machine vision.
II. Low resolution image contain the less amount of information as compared to the high resolution image. More information is required for image analysis specially in satellite imaging.

Stationary wavelet transform [17] is another variants of wavelet transform which is same as the DWT with the exception that it does not down-sample the image and hence all the frequency bands has the size of original image. Stationary wavelet transform is also used in various image processing application.

This paper present a resolution enhancement algorithm which is able to produce a sharp high resolution image. Proposed method utilize the properties of DWT(Discrete wavelet transform) and SWT(Stationary wavelet Transform).

Proposed method starts by decomposing the low resolution image in to different frequency sub-bands. All the three high frequency coefficients are then interpolated with the help of bi-cubic interpolation. SWT is used in this algorithm to obtain the high frequency component of the input image which is then added to the interpolated high frequency component for correct estimation of the high frequency component. At last, Inverse discrete transform is applied to get the high resolution enhancement techniques.

METHODOLOGY

In the proposed methodology, Discrete wavelet transform and Stationary wavelet transform is used for enhancing the resolution of the image. Discrete wavelet transform basically divide the image in to four different frequency sub-band known as the low frequency coefficient (LL), Horizontal frequency coefficients (LH), Vertical frequency coefficients (HL) and High frequency Coefficients (HH). Out of these frequency coefficients, Horizontal and Vertical frequency coefficients are known as the mid frequency coefficients. In wavelet decomposition, all the above mentioned coefficients are obtained by down sampling the signal or image. So all theses different frequency coefficients are of size which is just half of the size of the original image. In order to enhance the resolution of the image, interpolation method is commonly used in spatial domain.

Block diagram of proposed methodology is shown in the figure1. The procedural steps are described in the next section.

Step 1: first of all high resolution image of dimension 512x512 is taken and then with the help of Gaussian smoothing filter it is down sampled by factor 2 to produce low resolution image of dimension 256x256.

Step 2: Low resolution image obtained in the first step is divided in to 4 frequency sub-bands i.e. LL (Low frequency component), LH (Low high frequency Component), HL (High-low frequency component) and HH (HIGH frequency component). All the 4 frequency sub-bands obtain in this step has the dimension size which is half of the dimension size of input low resolution image.

Step 3: SWT(Stationary wavelet Transform) is also applied to the low resolution input image to get the 4 frequency sub-bands i.e. LL(Low frequency component), LH(Low high frequency Component) ,HL(High-low frequency component) and HH(HIGH frequency component) . Dimension size of these frequency sub-bands is same as the size of low resolution input image.

Step 4: Frequency sub-bands LH,HL and HH obtained by DWT decomposition is then undergoes interpolation operation (Bi-cubic) by a factor of 2 to get the double dimension size frequency sub-bands. Now these sub-bands are added to the corresponding frequency component obtained by the SWT in the previous step to get the estimated LH,HL,HH frequency component.

Step 5: In this step, estimated LH,HL,HH frequency component are again interpolated by factor ½.At the same time input low resolution image is also interpolated with the factor ½ . This Interpolated image work as the estimated LL frequency component.

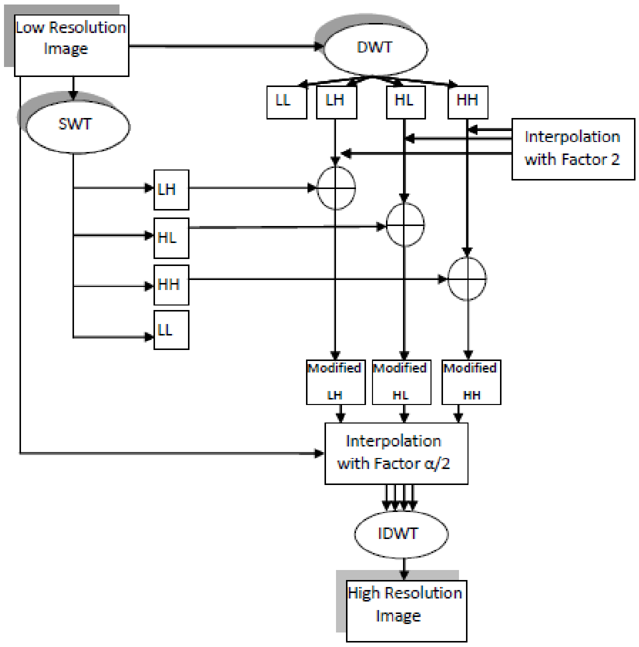

Figure 1. Block Diagram of Proposed Algorithm

Step 6: Frequency component obtained from previous two step i.e. LL, LH, HL and HH is taken and inverse discrete transform is applied to get the high resolution image. For performance comparison, Bi-cubic interpolation method and WZP (wavelet zero padding) method Is also applied to same low resolution image to get the high resolution image.

EXPERIMENTAL RESULTS

Since image resolution enhancement is very useful for satellite images and medical images for extracting out the minutes details therefore it is very important to test the performance of proposed method in different kind of images. Images of three different categories i.e. General image, Satellite image and medical image has been taken to test the performance of proposed method.

First of all high resolution images of all the three categories has been taken and then it is converted to low resolution image. Then proposed method is applied to these low resolution images to obtain the high resolution images. In order to compare the performance of proposed method, bi-cubic interpolation method and WZP method is also applied to these images to obtain the high resolution image from these methods. PSNR and MSE is computed for all the result obtain for all the three method. Whole process is performed under MATLAB Version R2010a for the system having 2GB RAM and Core2duo processor.

The result obtain by applying the bi-cubic, WZP, DWT and Proposed method to low resolution satellite image "Chicago.jpg" is shown in figure 2.

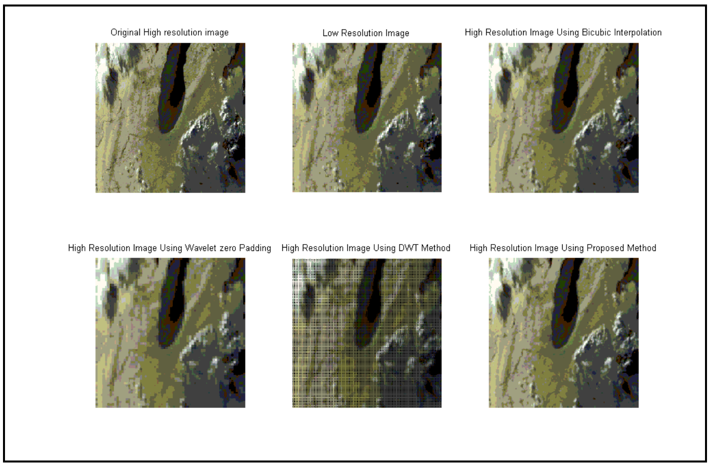

Figure 2. Result Illustration of low resolution "Chicago.jpg (128x128)" image to high resolution image (256x256) for different techniques.

Same methods are applied to the low resolution satellite image "server.jpg" and obtained results is given in the figure 3.

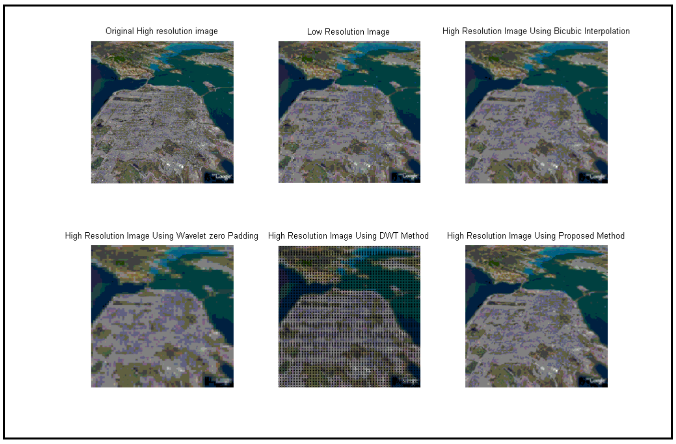

Figure 3. Results of low resolution "server.jpg (128x128)" image to high resolution image (256x256) for different techniques.

Table 1. PSNR, SSIM IQI Comparison

For testing the proposed method for low resolution satellite image "gun256.jpg", all the four method are also

Image	Method	PSNR (in dB)	SSIM	Image Quality Index
Chicago 256.jpg	Bi-cubic	58.6875	0.0053	0.9988
	WZP	54.0302	0.0052	0.9870
	DWT	38.4136	0.0115	0.9286
	SWT-DWT	60.4149	0.1104	0.9955
Gun256 .jpg	Bi-cubic	54.0847	0.0015	0.9999
	WZP	49.0600	0.0016	0.9993
	DWT	38.3417	0.0024	0.9246
	SWT-DWT	66.5905	0.1017	0.9953
E_server.jpg	Bi-cubic	55.8643	0.0110	0.9698
	WZP	46.1920	0.0119	0.9594
	DWT	37.4031	0.0208	0.8658
	SWT-DWT	63.0317	0.1174	0.9952

applied to satellite image "gun256.jpg" and obtained high resolution image is shown in figure 4.

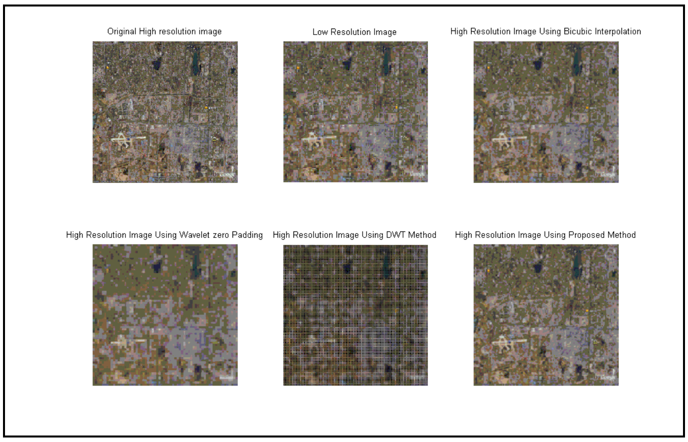

Figure 4. Results of low resolution "gun256.jpg (128x128)" image to high resolution image (256x256) for different techniques.

Apart from visual comparison, statistical parameter were also computed for better understanding of performance. For this PSNR, SSIM (Structural Similarity Index Measure) and IQI (Image Quality Index) is computed and tabulated in Table1.

Figure5 Shows the graph for PSNR for all the three methods.

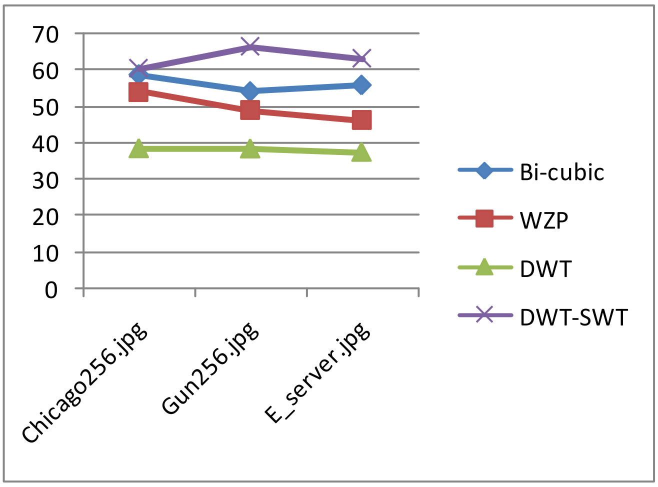

Figure5. PSNR graph for different Techniques of Image Resolution Enhancement.

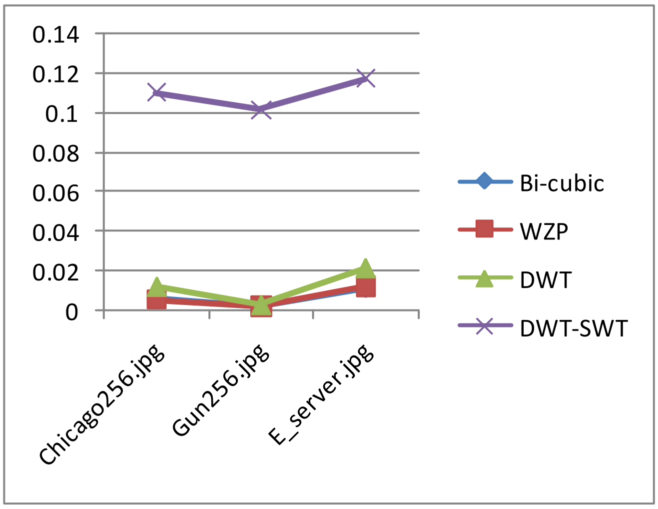

Figure6. SSIM Comparison Graph for different Techniques of Image Resolution Enhancement.

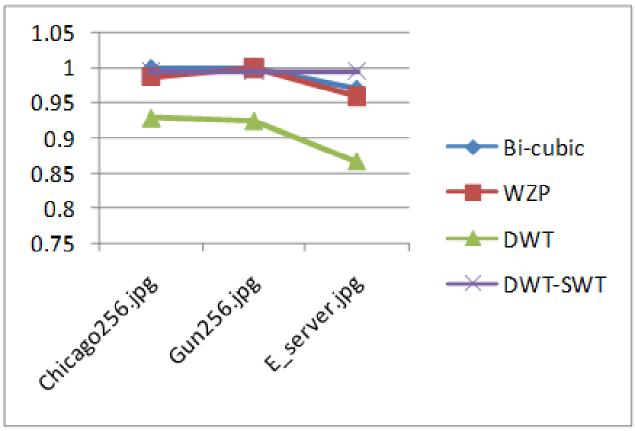

Figure7. IQI Comparison Graph for different Techniques of Image Resolution Enhancement.

Conclusion

Image resolution enhancement is one of the significant operations of image processing aiming to get the high resolution image and extract out the details of the image. In this paper, Combination of DWT-SWT and Bi-cubic interpolation based method is implemented. Proposed method is compared with the past methods of resolution enhancement. PSNR and MSE metrics are used to compare the performance of the proposed method. Visual results and the computed parameters value suggest the supremacy of the proposed method over past method. In future, other variants of wavelet transform can also be combined to explore the possibility of getting better results.

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