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Comparison of Wavelet Transform with Various Technique for Satellite Image Enhancement

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ABSTRACT

In this paper, a method for satellite image enhancement based on wavelet transform is presented. First, a satellite image is decomposed by Haar wavelet transform, and then all the high frequencies sub bands are decomposed again. An original image is interpolated with half of the interpolation factor used for interpolation the high frequency sub bands. Then, the inverse wavelet transform is applied to obtain the enhanced image. The experimental result shows that the proposed algorithm making good enhancement.

Keywords: Image enhancement, Wavelet Transform, Haar transform.

1. INTRODUCTION

These days satellite images are being used in dissimilar fields, so it is essential to have high resolution satellite images. Satellite images are unnatural by various factors such as absorption;scattering etc in the space,resolution of these similes is very low. To have better observation of these images it is necessary to have the image with clear and well defined edges, which provides better visible line of separation etc. Resolution enhancement of these images has always been a major issue to extract more in sequence from them. There are many approaches that can be used to enhance the resolution of a satellite image. Wavelet domain based methods have proved themselves as most efficienttechnique serving for the required purpose. Interpolation in image processing is a well-known method to increase the resolution of a digital image. Many interpolation techniques have been developed to increase the image resolution

A new framework for statistical signal processing based on wavelet-domain hidden Markov models (HMM's) that concisely models the statistical dependencies and non-Gaussian statistics encountered in real-world signals is developed in [1]. Efficient expectation maximization algorithms are developed for fitting the HMM's to observational signal data.

A wavelet domain image resolution enhancement algorithm is developed in [2]. A primary high-resolution approximation to the original image is obtained by means of WZP and is further processed using the CS methodology which reduces ringing. An efficient edge algorithm is used for the description of edge degradations such as blurring due to loss of resolution. Linear regression using a minimal training set of high-resolution originals is finally employed to rectify the degraded edges. A multiple description image coding scheme is proposed to facilitate the transmission of images over media with possible packet loss and is based on finding the optimal reconstruction filter coefficients that will be used to reconstruct lost descriptions in [3].

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For this purpose initially, the original image is down sampled and each sub image is coded using standard JPEG. These decoded images are then mapped to the original image size using the optimal filters. Interpolation of the high-frequency sub band images obtained by dual-tree complex wavelet transform (DT-CWT) is proposed in [4]. DT-CWT is used to decompose an input low-resolution satellite image into different sub bands. Then, the high-frequency sub band images and the input image are interpolated, to generate a new HR image by using inverse DT-CWT.

The resolution enhancement is achieved by using directional selectivity provided by the CWT, where the high-frequency sub bands in six different directions contribute to the sharpness of the high-frequency details such as edges. Super resolution is used for resolution enhancement of images or video sequences. Instead of super resolving frames globally, using localized motion based super resolution increases the quality of the enhanced frames. The super resolution on different sub bands of localized moving regions extracted from discrete wavelet transform (DWT) and composing the super resolved sub bands using inverse DWT (IDWT) to generate the respective enhanced high resolution frame in [5].

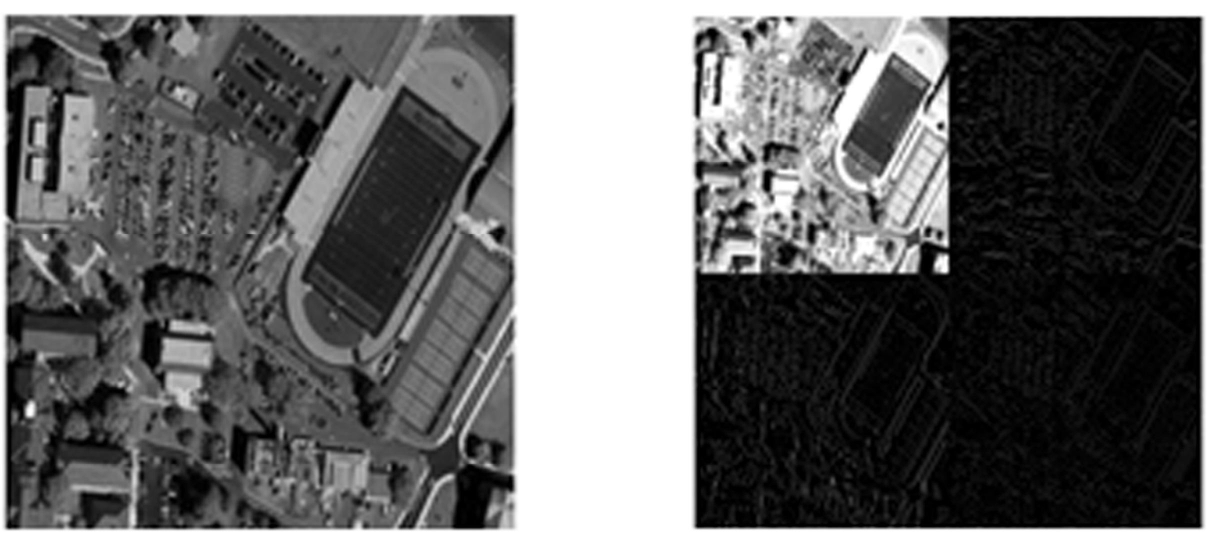
2. METHODOLOGY

The proposed Image Enhancement system is based on DWT. In this following section the theoretical background of all the approaches are introduced.

2.1. Discrete Wavelet Transform

Nowadays, wavelets have been used quite frequently in image processing and used for feature extraction, de-noising, compression, face recognition, and image super-resolution. The decomposition of images into different frequency ranges permits the isolation of the frequency components introduced by “intrinsic deformations” or “extrinsic factors” into certain sub-bands. This process results in isolating small changes in an image mainly in high frequency sub-band images.

The 2-D wavelet decomposition of an image is performed by applying 1-D DWT along the rows of the image first, and, then, the results are decomposed along the columns. This operation results in four decomposed sub-band images referred to as low–low (LL), low–high (LH), high–low (HL), and high–high (HH). The frequency components of those sub-band images as shown in Figure 1 (b) cover the frequency components of the original image in Figure 1 (a).



(a) (b)

Figure 1: (a) Input Image (b) 2-D Wavelet decomposition

2.2. Interpolation Techniques

Interpolation is the process of estimating the values of a continuous function from discrete samples. Image processing applications of interpolation include image magnification or reduction, sub pixel image registration, to correct spatial distortions, and image decompression, as well as others. Of the many image interpolation techniques available, nearest neighbor, bilinear and cubic convolution are the most common, and will be talked about here.

Since, Interpolation provides a perfect reconstruction of a continuous function, provided that the data was obtained by uniform sampling at or above the Nyquist rate. Since Interpolation does not give good results within an image processing environment, since image data is generally acquired at a much lower sampling rate. The mapping between the unknown high-resolution image and the low-resolution image is not invertible, and thus a unique solution to the inverse problem cannot be computed. One of the essential aspects of interpolation is efficiency since the amount of data associated with digital images is large.

$$u(s) \ = \{0 \mid s \mid > 1$$
$$\{1 - \mid s \mid \mid s \mid < 1$$

2.2.1. Bilinear Interpolation

Bilinear Interpolation determines the grey level value from the weighted average of the four closest pixels to the specified input coordinates, and assigns that value to the output coordinates. First, two linear interpolations are performed in one direction and then one more linear interpolation is performed in the perpendicular direction. For one-dimension Linear Interpolation, the number of grid points needed to evaluate the interpolation function is two. For Bilinear Interpolation (linear interpolation in two dimensions), the number of grid points needed to evaluate the interpolation function is four [6]. For linear interpolation, the interpolation kernel is: where, s is the distance between the point to be interpolated and the grid point being considered. The interpolation coefficients

$$c_k = f(x_k)$$

2.2.2. Bicubic Convolution Interpolation

Cubic Convolution Interpolation determines the grey level value from the weighted average of the 16 closest pixels to the specified input coordinates, and assigns that value to the output coordinates. The image is slightly sharper than that produced by Bilinear Interpolation, and it does not have the disjointed appearance produced by Nearest Neighbour Interpolation. First, four one-dimension cubic convolutions

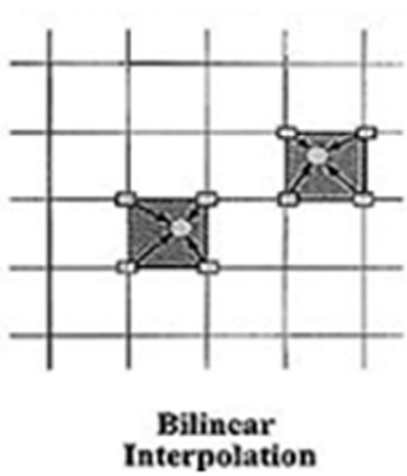


Figure 2: Bilinear Interpolation

are performed in one direction and then one more one-dimension cubic convolution is performed in the perpendicular direction. This means that to implement a two-dimension cubic convolution, a one-dimension cubic convolution is all that is needed. For one-dimension Cubic Convolution Interpolation, the number of grid points needed to evaluate the interpolation function is four, two grid points on either side of the point under consideration. For Bicubic Interpolation (cubic convolution interpolation in two dimensions), the number of grid points needed to evaluate the interpolation function is16, two grid points on either side of the point under consideration for both horizontal and vertical directions [7] . The original image quality is poor, but the contrast between the pixilation of sampling and the smoother bicubic interpolation.

3. PROPOSED METHODS

Discrete wavelet transform based technique is most widely used technique for performing image interpolation is presented in this paper. Here DWT is used to decay a low resolution image into 4 subband images LL, LH, HL and HH. All the obtained low and high-frequency components of image are then interpolated. A difference image is obtained by subtracting the interpolated LL image from the original low resolution image. This difference image is then added to the interpolated high frequency components to obtain estimated form of HF subband images. Finally IDWT is used to combine these estimated images along with the input image to obtain high resolution images. The block diagram is shown in figure 1.

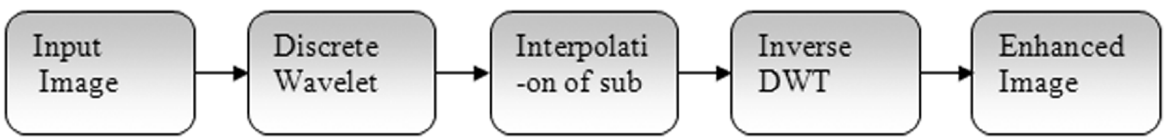


Figure 3: Block Diagram of the proposed method

4. EXPERIMENTAL RESULTS

Performance analysis of various resolution enhancement algorithms in wavelet domain is done and measured in terms of metrics such as PSNR as tabulated above. Table 1 and 2 are calculated metrics value for different algorithms.

The PSNR is defined as

$$PSNR = 10 \ \log_{10} \frac{(peak\ to\ peak\ value\ of\ the\ reference\ diamge)^2}{\sigma_e^2}$$

Here, peak to peak value of the referenced image is the maximum pixel value of the image. When the pixels are represented using 8 bits per sample, this is 255. The peak signal to noise ratio is calculated from the error using the above formula. The higher the value of the PSNR, the better is the performance of that particular local operator for the noise added. From the table, PSNR value of our proposed method is higher than other methods.

Table 1
MSE and PSNR results for different techniques

Method	*MSE*	*PSNR*
WZP	0.0967	32.722
CS	0.0706	27.4267
DWT/Bilinear	0.0664	51.7852

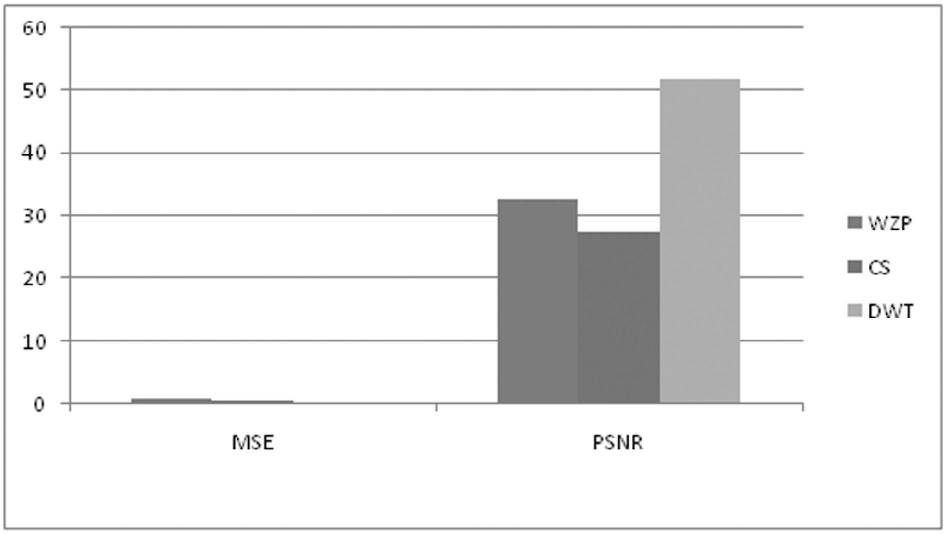


Figure 4: Graphical representation of MSE and PSNR of various methods with DWT

5. CONCLUSION

Based on the above analysis, by considering all three factor simultaneously and observing the result it can be concluded that DWT is the most efficient method for satellite image resolution enhancement. High performance of DWT is due to shift invariance and directional selectivity.

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