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Satellite Image Resolution Enhancement using Quadrated Discrete Wavelet Transform

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ABSTRACT

Satellite images are being widely used in many fields. One of the major issues of these types of images is their resolution. The most important quality factors of the images come from its resolution. Interpolation is a known method to increase the resolution of a digital image. A satellite image resolution enhancement technique based on the interpolation of the high-frequency sub bands obtained by discrete wavelet transform (DWT) and the input image is a new proposed technology. The proposed resolution enhancement technique uses DWT to decompose the input image into different sub bands. Then, the high-frequency sub band images and the input low-resolution image have been interpolated by using quadratic interpolation, followed by combining all these images to generate a new resolution-enhanced image by using inverse DWT. By employing DWT with quadratic interpolation, it is possible to recover the high frequency components of the input image which provides with a good visual clarity on the edges of the images and thus enhanced high resolution images are obtained.

Introduction

Image enhancement techniques improve the quality of an image as perceived by a human. These techniques are most useful because many satellite images when examined on a color display give inadequate information for image interpretation. Resolution of an image has been always an important issue in many image and video-processing application. Interpolation in image processing is a method to increase the number of pixels in a digital image [2]. Interpolation-based image resolution enhancement has been used for a long time and many interpolation techniques have been developed to increase the quality of this task. There are three well-known interpolation techniques, namely, nearest neighbour, bilinear, and bicubic [3]. Bicubic interpolation produces smoother images. Wavelets are also playing a significant role in many image-processing applications. The 2-D wavelet decomposition of an image is performed by applying the 1-D discrete wavelet transform (DWT) along the rows of the image first, and then the results are decomposed along the columns [6]. This operation results in four decomposed sub band images referred to low-low (LL) low-high (LH), high-low (HL), and high-high (HH). A filter bank should operate on the image in order to generate different sub band frequency images [5].Due to some articrafts, quadratic interpolation is a proposed technology. Edges identified by an edge detection algorithm in lower frequency sub bands were used to prepare a model for estimating edges in higher frequency sub bands and only the coefficients with significant values were estimated [7]

The fig1 shows the block diagram for applying DWT with Bicubic interpolation on satellite image. Here, the Discrete Wavelet Transform (DWT) is used to preserve the high-frequency proposed resolution enhancement process. In other words, low frequency sub band images are the low resolution of the original image. Instead of using low-frequency sub band images, which contains less information than the original input image, we are using the input image through the interpolation process.

Block diagram

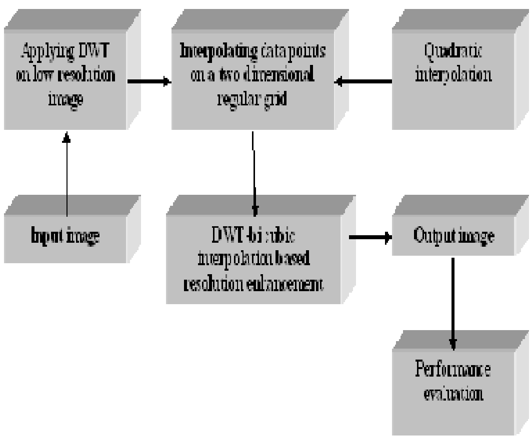

Fig 1. Block diagram for DWT with Bicubic Interpolation

The input low-resolution image is interpolated with the half of the interpolation factor, α/2.DWT separates the image into different sub band images, namely, LL, LH, HL and HH. A high-frequency sub band contains the high frequency component of the image. The interpolation can be applied to these four sub band images. In the wavelet domain, the low-resolution image is obtained by low-pass filtering of the high-resolution image. The low resolution image (LLsubband), without quantization (i.e., with double-precision pixel values) is used as the input. To preserve more edge information, i.e., obtaining a sharper enhanced image, an intermediate stage in high frequency sub band interpolation process is used. The low-resolution input image and the interpolated LL image with factor 2 are highly correlated. The difference between the LL sub band image and

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the low-resolution input image are in their high-frequency components. The difference image is used as the intermediate process to correct the estimated high-frequency components. This estimation is performed by interpolating the high-frequency sub bands by factor 2 and then including the difference image into the estimated high-frequency images, followed by another interpolation with factor α/2.Then the Inverse Discrete Wavelet Transform (IDWT)is performed with the low resolution input image and the interpolated high frequency sub bands to get high resolution output image.

Performance evaluation

Peak signal-to-noise ratio (PSNR) and root mean square error (RMSE) have been implemented in order to obtain some quantitative results for comparison.Peak signal-to-noise ratio, often abbreviated PSNR, is an engineering term for the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation. PSNR can be obtained by using the following formula

$$PSNR = 10\log_{10}\left(\frac{R}{MSE}^{2}\right)$$

where R is the maximum fluctuation in the input image (255 in here as the images are represented by 8 bit, i.e., 8-bit grayscale representation have been used—radiometric resolution is 8 bit); and MSE is representing the MSE between the given input image I_{in} and the original image I_{org} which can be obtained by the following.

$$MSE = \frac{\sum_{i,j}(I_{in}(i,j) - I_{org}(i,j))^2}{M \times N}$$

Where M and N are the size of the images.

Results

A low resolution satellite image taken as an input image is shown in fig 2

Fig 2. Original image

The figure 2 shows the low resolution satellite image. The image is given as input to the DWT to get four sub band images. The quadratic interpolation is applied to the four sub band images and finally IWDT is applied to get the final resolution image.

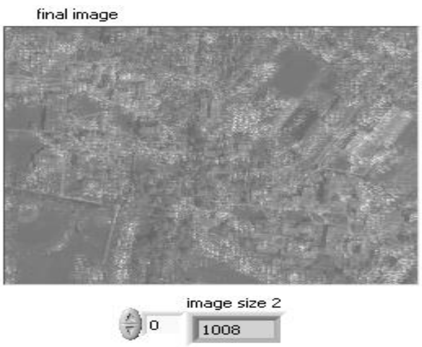

Fig 3. Reconstructed image

Fig 3 shows the reconstructed image obtained using Inverse Discrete Wavelet Transform. The MSE value is calculated and compared for various interpolation techniques.Fig4. illustrates the table showing the calculated MSE values for different interpolation techniques.

Fig 4. Comparision of MSE for different interpolation techniques

S.NO	METHOD	MSE
1	Bi-cubic	12788.8
2	Bilinear	13479.5
3	Zero order	13048.8
4	Quadratic	1631.58

Fig 4 clearly illustrates that quadratic interpolation technique have higher Mean Squared Error. By using this PSNR value is calculated.

Fig 5. Comparison of PSNR for different Interpolation techniques

S.NO	METHOD	PSNR
1	Bi-cubic	13.9255
2	Bilinear	13.862
3	Zero order	13.6824
4	Quadratic	21.5848

Fig 5 shows that Quadratic interpolation has higher PSNR value. This clearly suggests that quadratic interpolation can be applied to get fine resolution image.

Fig 6 &Fig 7 shows the graphical representation for comparison of MSE and PSNR for different interpolation techniques.

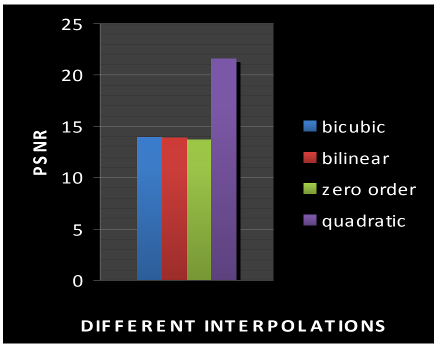

Fig 6. Comparison of MSE

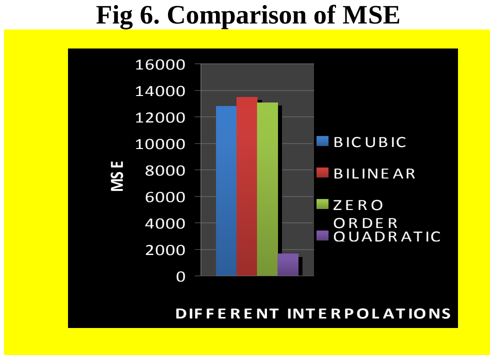

Fig 7. Comparison of PSNR

Fig 6 &Fig 7 clearly illustrates that the proposed quadratic interpolation provides fine results when compared with other interpolation techniques.

Conclusion

The use of discrete wavelet transform and quadratic interpolation techniques provide better high resolution images. The major details of the images present in the high sub band images are enhanced by quadratic interpolation and the edge detection method. Thus the finer details of the image are expected by using discrete wavelet transform, quadratic interpolation and intermediate image.

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