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DWT Based Image Super Resolution Performance Analysis

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Abstract - *In computer vision field, Image resolution enhancement has become the most current research area. Improving image resolution by applying costly hardware is expensive and time-consuming. Many algorithms have been developed by researchers based on Projection Onto Convex Set (POCS), Maximum-aposteriori(MAP) and Maximum Likelihood (ML) In this paper, we analyzed a super resolution algorithm based on Discrete Wavelet Transform(DWT). Single frame super resolution can be achieved by use of different interpolation method but this scheme generates blur at the edges of images. Hence in this paper we relied on wavelet transform for super resolution algorithm with different orthogonal and bi-orthogonal filters. Quality aspect of images such as MSE, PSNR, SSIM and Correlation Coefficient(CC) are calculated with this proposed algorithm.*

Key Words: DWT, MSE, PSNR, SSIM, CC, Super Resolution.

1.INTRODUCTION

The high resolution image has high pixel density due to which it gives more details of information which are required in critical applications such as medical diagnosis, satellite surveillance and mammographic images. The high resolution image has high pixel density due to which it gives more details of information which are required in critical applications such as medical diagnosis, satellite surveillance and mammographic images. In recent years, many new algorithms of reconstruction of high resolved image have been proposed. There are many well-known existing methods for the super-resolution which are based on the standard interpolation techniques (pixel replication, bilinear, bi-cubic, linear interpolation) that increase the pixel count without adding the details [1],[2] and [3]. Super-resolution technique can be divided into three types: spatial domain reconstruction, Frequency domain reconstruction, and probability based methodssuper-resolution technique can be divided into three types: spatial domain reconstruction, Frequency domain reconstruction, and probability based methods. The approach by Irani et al [4] in reconstructing a high-resolution image handles dynamic images of an object, and more complex motions than pure translational motion in the image plane. Their algorithm is based on generating a set of simulated low-resolution images. Gajjar et al [1] obtained high frequency sub-bands derived from Discrete Wavelet Transform (DWT) in their a learning-based approach for super-resolving an image using single observation. They have used orthogonal wavelet filter bank (db4) to extract the high frequency components from the low resolution image. Ji et al [5] proposed super-resolution algorithm in which they have addressed the problem of frame alignment and image restoration based on standard biorthogonal wavelet filter bank (cdf-9/7). The motivation for this paper is work carried by Demirel et al for image enhancement. As different super resolution algorithms are developed in past years using wavelet transform.Demirel et al [7] carried out a lot of work based on image enhancement using wavelet transform. However it is found that along with wavelet transform, various standard filter banks can be implemented and find out suitable filter bank for image enhancement algorithm.

2. Proposed DWT Based Analysis

Hasan Demirel et al developed interpolation based a super-resolution technique. In their algorithm, low resolution image is transformed to different sub-bands frequencies using discrete wavelet transform. Further these high frequency sub-bands are interpolated using various interpolation method (nearest, bilinear and bi-cubic interpolation). Super resolved image is obtained by inverse transformed of a combination of interpolated high frequency sub-bands and the input image. In their algorithm, they have proved that quality of the image is enhanced using this wavelet based technique in comparison with a super resolved image obtained by a different interpolation method. The block diagram of the method proposed by Demirel et al is shown in figure 1.

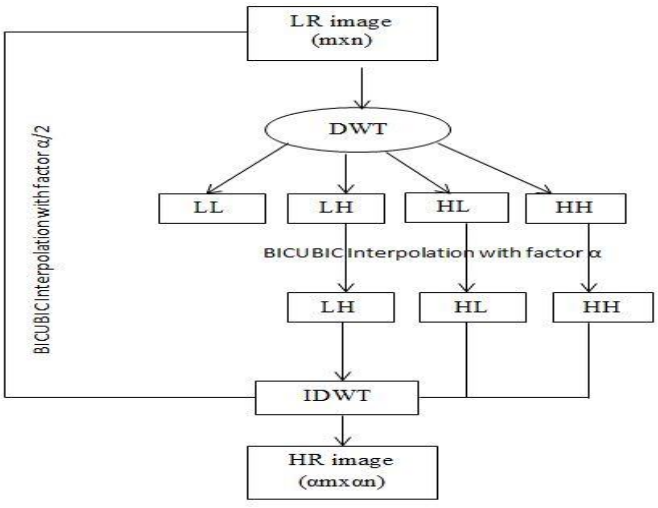

Fig.1 DWT base Image Super Resolution Algorithm

The work has been done as:
Initially down sampling is applied on the input image to Obtain blurred , noisy low resolution image. The input image is transformed to different frequencies sub-bands using Discrete Wavelet transform. While transforming of image different orthogonal and Biorthogonal filters are used like db1,db2,db3,bior1.5 and bior3.5. Finally SR image is obtained by applying an inverse transformation of DWT with different filters on sub-bands and interpolated image.

3. RESULT AND DISCUSSION

Super resolution algorithm is performed over different images from various application fields with standard filters (db1, db2, db3, bior 1.5 and bior 3.5). Each image is transformed to sub-bands with DWT wavelet transform. The algorithm is implemented in MATLAB software where the size of input images are 128×128 and we obtained super resolved images of size 512x512. For performance evaluation of this algorithm, following quality parameter of the image is used.

$$MSE = \frac{\sum_{i=0}^{I-1}\sum_{j=0}^{J-1}((\hat{f}(x,y) - f(x,y))^2}{\sum_{i=0}^{I-1}\sum_{j=0}^{J-1}(f(x,y))^2}$$

$$RMSE = \sqrt{MSE}$$

$$PSNR = 10\log_{10}\frac{R^2}{MSE}$$

$$CC = \frac{\sum_{i=0}^{I-1}\sum_{j=0}^{J-1} d1d2}{\sum_{i=0}^{I-1}\sum_{j=0}^{J-1} d1 \sum_{i=0}^{I-1}\sum_{j=0}^{J-1} d2}$$

$$SSIM = \frac{(2\mu_f\mu_{\hat{f}} + C_1)(2\sigma_{f\hat{f}} + C_2)}{(\mu^2{}_f + \mu_{\hat{f}}{}^2 + C_1)(\sigma_f{}^2 + \sigma^2{}_{\hat{f}} + C_2)}$$

Where C1, C2 are constants and σ_f, $\sigma_{\hat{f}}$ are the standard deviations of the images.

For each standard filter above parameters are calculated and results are shown in table 1, table 2, table 3 and table 4 with images real time image (job), Lena, Butterfly, Pirate and Elaine image respectively. The corresponding images which are used for experimentation are shown in figure2, figure3, figure4 and figure5.

Fig.2 Original and HR Lena image

Fig. 3 Original and HR image of Butterfly

Fig. 4 Original and HR image of Pirate

Fig. 5 Original and HR image of Elaine

Table -1: Evaluation of quality parameter of Lena image

Wavelet	PSNR	MSE	SSIM	CC
db1	33.7856	42.5643	0.7586	0.8944
db2	34.9432	28.3777	0.8882	0.9136
db3	23.8332	402.8221	0.7839	0.8821
Bior1.5	31.5432	283.3821	0.6038	0.7932
Bior3.5	29.9221	200.8291	0.6321	0.7981

Table -2: Evaluation of quality parameter of Butterfly image

Wavelet	PSNR	MSE	SSIM	CC
db1	30.7382	40.2911	0.8583	0.9324
db2	32.8213	30.4832	0.8693	0.9556
db3	28.9939	409.9492	0.7792	0.8732
Bior1.5	29.9392	200.9381	0.7192	0.8832
Bior3.5	29.9921	199.8382	0.7999	0.9111

Table -3: Evaluation of quality parameter of Pirate image

Wavelet	PSNR	MSE	SSIM	CC
db1	29.9392	59.8382	0.8282	0.9090
db2	30.8372	41.8422	0.8789	0.9234
db3	25.8483	240.8948	0.7111	0.8123
Bior1.5	27.8392	199.8481	0.7932	0.8932
Bior3.5	27.9922	198.848	0.8080	0.9111

Table -4: Evaluation of quality parameter of Elaine image

Wavelet	PSNR	MSE	SSIM	CC
db1	31.3921	64.8932	0.8922	0.9444
db2	33.8939	49.8392	0.9032	0.9667
db3	28.9943	299.8993	0.7123	0.8645
Bior1.5	30.8821	178.8921	0.7325	0.8783
Bior3.5	30.9822	177.8921	0.7434	0.8821

4. CONCLUSION

In this algorithm, DWT is used to obtain high resolution image. In this wavelet transform, we tried to implement standard orthogonal and bi-orthogonal filters for the different images as mentioned above. Different images are chosen whose frequency spectrum is varying considerably. The responses of all these wavelet filter banks to these images are drastically changes. The quality parameters for all image found good for the filter bank db2 which is orthogonal. It is observed that the db2 wavelet gives the better performance than other wavelets due to its orthogonality property, and good reconstruction property.

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