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HYBRID TRANSFORMATION TECHNIQUE FOR IMAGE COMPRESSION

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ABSTRACT

Digital image in their raw form require a huge amount of storage capacity so that a scheme that produces high degree of compression is required which should preserve the critical image information. In this paper, data compression for images using hybrid DWT-DCT is used which performs discrete cosine transformation on the discrete wavelet transformed coefficients. This method gives high compression ratio, preserving most of the image information and the image is reproduced with good quality. Generally for getting high compression ratio, we have to trade off the clarity of the image. In this paper, three case studies has been discussed so that the most suitable case for a particular application can be taken and implemented. The new scheme reduces blocking artifacts, ringing effects and false contouring appreciably. The compression ratio that is obtained from this method is more when compared to currently used standards of Image compression, preserving most of the image information. The first case has a very high compression ratio; but for getting that the clarity of the image is partially traded off. Second case is more suitable for regular applications as it is having a good compression ratio along with preserving most of the information. In the third case, more importance is given to the image information. Also an Image sharpening technique which is generally not used as a part of Image compression technique, is used in this paper through which we can almost get back the lost information during the compression process.

Keywords: *Discrete Wavelet Transform, Discrete Cosine transform, Hybrid transform, Arithmetic Length Coding, SSIM, PSNR, Compression Ratio*

1. INTRODUCTION

Data compression is a process of reducing the amount of data required to represent a given quantity of information. The data and information are not the same; data are the means by which information is expressed. Since various amounts of data can be used to represent the same amount of information, representations that are irrelevant or repeated information are said to contain redundant data. Most 2D intensity arrays contain information that is ignored by the human visual system and/or irrelevant to the intended use of image. Data compression it is one of the most used techniques in the field of image processing.

JPEG was developed in 1992, using the DCT [1] is simple and it is the widely used technique for compression, but results in blocking artifacts, ringing effects and false contouring appreciably for high compression ratio [2]. Discrete Wavelet Transform (DWT) based coding, is another efficient technique used for image compression [3-4]. The ability to display image at different resolutions like low frequencies and high frequencies simultaneously makes it a better method compared to others.

Utilizing the benefits of both (DWT-DCT) popular coding techniques a new technique known as hybrid transform technique has been introduced where these two coding schemes are implemented together. A few efforts are devoted to such hybrid implementation in research area nowadays. In [5], a hybrid transformation scheme for video coding is presented, which minimizes prediction error. In [6], Yu and Mitra introduced another form of hybrid transformation technique. In [7], Singh et al. used a hybrid algorithm for medical images that uses 5-level DWT decomposition. But higher level schemes require large computational resources and are not suitable for use in modern coding standards.

In this paper, an efficient hybrid DWT-DCT technique for image compression is presented in which the 2-level 2-D DWT is taken followed by applying the 8-point 2-D DCT. The DCT is applied only to the DWT low-frequency components that results in higher compression ratio (CR) preserving important information. Three cases have been taken in account in which each case depends upon the consideration of different subimages of DWT

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output. The result shows performance improvement with least false contouring and a higher compression ratio is achieved compared to the other standard stand alone schemes.

2. 2-D DISCRETE WAVELET TRANSFORMATION (DWT)

Wavelets are functions defined over a finite interval and have an average value equal to zero. The wavelet transform is to represent any arbitrary function (t) as a superposition of a set of basis functions. These basis functions or baby wavelets are obtained from a single prototype wavelet called the mother wavelet. The basis functions include scaling function and wavelet function. The image is first divided into 32 x 32 blocks and each block is then passed through the two filters: scaling filter (basically a low pass filter) and wavelet filter (basically a high pass filter). Four subimages are formed after doing the first level of decomposition namely LL, LH, HL, and HH coefficients. Except the LL coefficients, all the coefficients are discarded, which are transformed into the second level.

Forward DWT:

Based on the separable kernel property, a two dimensional discrete wavelet transform for a two dimensional signal (image) can be implemented by applying one-dimensional transform twice; one row wise and other column wise. The 1st level DWT is represented in figure 1. LL is the approximation image of the input image as we get that image by passing the input image through low pass filters row wise and column wise. Therefore only low frequency details will be present in that image both row wise and column wise. LH is the vertical detail image as it contains vertical details of input image. HL subimage carries the horizontal details of the input image and HH carries the diagonal details.

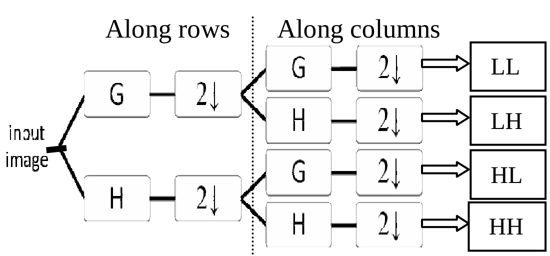

Figure 1. Block Diagram for Forward 1st level DWT

Reverse DWT:

The reverse process of the DWT is shown in figure 2. Here along with the synthesis filters, upsamplers are used. The four sub images bring back to a reconstructed image which is used in the decoding side. i.e. at the receiver side.

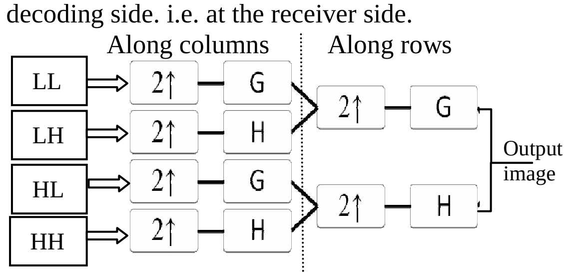

Figure 2. Block Diagram for Reverse 1st level DWT

3. 2-D DISCRETE COSINE TRANSFORM (DCT)

The discrete cosine transform (DCT) is a technique for converting a signal into elementary frequency components. One of the advantages of DCT is the fact that it is a real transform, whereas DFT is complex. This implies lower computational complexity, which is sometimes important for real-time applications. The 2_{nd} level decomposed image, i.e. the LL coefficients which is decomposed using DWT is taken as the input image for DCT. It is then divided into 8×8 blocks and 8-point 2-D DCT is applied to each block. The equations for forward and inverse DCT are shown in equations (1) and (2).

FDCT:

$$S_{uv} = \frac{1}{4} C_u C_v \sum_{x=0}^{7} \sum_{y=0}^{7} S_{yx} \cos\frac{(2x+1)u\pi}{16} \cos\frac{(2y+1)v\pi}{16} \quad \text{.... (1)}$$

IDCT:

$$S_{yx} = \frac{1}{4} \sum_{u=0}^{7} \sum_{v=0}^{7} C_u C_v S_{vu} \cos\frac{(2x+1)u\pi}{16} \cos\frac{(2y+1)v\pi}{16} \quad \text{....(2)}$$

Where

$$C(i) = \begin{cases} \frac{1}{\sqrt{2}} & if \quad i = 0 \\ 1 & if \quad i > 0 \end{cases}$$

S_{yx} = 8*8 block of input image

S_{vu} = corresponding DCT coefficient

4. DCT QUANTIZATION AND ARITHMETIC CODING

DCT Quantization:

The DCT transformed coefficients are then quantized with the help of quantization tables separately for Y, Cb and Cr components. Each

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value of transformed coefficients are divided by the corresponding elements in the Q table and they are rounded off to the nearest integer as shown in Eq. (3).

$$S'(u,v) = round(S(u,v)/Q(u,v)) \qquad ....(3)$$

where
S(u,v) - DCT coefficient matrix
Q(u,v) - Quantization matrix

The quantization matrix is selected after conducting a sequence of psycho visual experiments and more weightage is given to dc coefficient and the initial ac coefficients. Remaining all values are approximated to zeros so that redundant information can be avoided.

16	11	10	16	24	40	51	61
12	12	14	19	26	58	60	55
14	13	16	24	40	57	60	59
14	17	22	29	51	87	80	62
18	22	37	56	68	109	103	77
24	35	55	64	81	104	113	92
49	64	78	87	103	121	120	101
72	92	95	98	112	100	103	99

(a)

17	18	24	47	99	99	99	99
18	21	26	66	99	99	99	99
24	26	55	99	99	99	99	99
47	66	99	99	99	99	99	99
99	99	99	99	99	99	99	99
99	99	99	99	99	99	99	99
99	99	99	99	99	99	99	99
99	99	99	99	99	99	99	99

(b)

Figure 3. Standard Quantization Tables for DCT
(a) Quantization Table For Y space
(b) Quantization Table For Cb,Cr space

Arithmetic coding:

Different coding techniques are there which can be broadly classified into fixed length and variable length coding of which variable length is more efficient. The number of bits will be less for variable length coding compared to fixed length coding for representing the same amount of information which supports more compression. Arithmetic coding is a variable-length entropy encoding. When a string is converted to bits using arithmetic encoding, frequently used characters will be stored with fewer bits and characters which will not come frequently will be stored with more bits, resulting in fewer bits used in total.

5. PROPOSED HYBRID DWT- DCT TECHNIQUE:

The properties of both the DWT and the DCT are exploited in the proposed hybrid DWT-DCT technique. The input image is first converted to YCbCr colour model from RGB model. Then the whole image is split into blocks of size 32 x 32. The blocks of the image are first decomposed using 2-D Forward DWT. From this Low-frequency coefficients (LL) are passed to the next stage and the high frequency coefficients (LH, HL, and HH) are just discarded for getting high compression ratio. The passed LL components are further decomposed using 2nd level 2-D DWT. 8-point DCT is then applied to these DWT coefficients. The next stage is quantization, where the lossy compression occurs in which the higher frequency components are rounded off to zero. Finally entropy coding (lossless compression) is performed using arithmetic coding technique. In the decoding side, the reverse procedure is followed which uses an image enhancement technique as its last process for rebuilding its fine details.

The encoder and decoder block diagrams are shown below which pictorially represents the working of the proposed technique.

Encoder

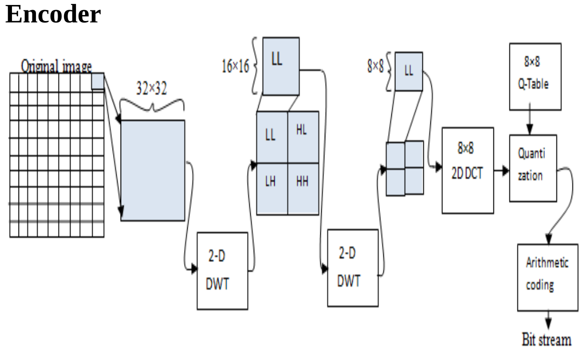

Figure 4(a). Block Diagram for Hybrid DWT-DCT encoder

Decoder

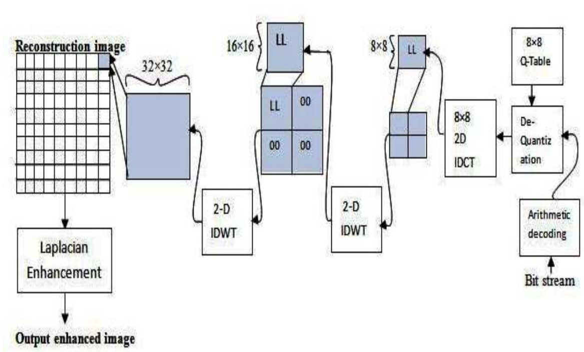

Figure 4(b). Block Diagram for Hybrid DWT-DCT decoder

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Laplacian Enhancement

Image sharpening is provided as the last stage in this paper so that the fine details of the image are extracted from the reconstructed image. For sharpening of an image first derivative and second derivative filters are widely used in which second derivative filters give stronger response to fine detail. Laplacian filter is widely used as second derivative filter as it is isotropic and it is easy to implement.

The Laplacian is defined as follows:

$$\nabla^2 f = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2}$$

where the partial 1st order derivative in the *x* direction and y direction is defined as follows:

$$\frac{\partial^2 f}{\partial x^2} = f(x+1, y) + f(x-1, y) - 2f(x, y)$$

&

$$\frac{\partial^2 f}{\partial y^2} = f(x, y+1) + f(x, y-1) - 2f(x, y)$$

So, the Laplacian can be given as follows:

$$\nabla^2 f = [f(x+1, y) + f(x-1, y) + f(x, y+1) + f(x, y-1)] - 4f(x, y)$$

We can easily build a filter based on this

0	-1	0
-1	4	-1
0	-1	0

Figure 5. Laplacian Kernel

The result of a Laplacian filtering is not an enhanced image. Subtract the Laplacian result from the original image to generate our final sharpened enhanced image.

$$g(x, y) = f(x, y) - \nabla^2 f$$

6. EVALUATION CRITERION

The performance of the hybrid DWT-DCT technique can be estimated using compression ratio (CR), Structural Similarity Metric Index (SSIM) and peak signal to noise ratio (PSNR). The Structural Similarity Metric (SSIM) index is another measurement technique that is perceives visual quality of the image.

1) PSNR

PSNR in dB is given by

$PSNR=10\log_{10}(I^2/MSE)$

Where I is the maximum intensity level

MSE – Mean Square Error

$$MSE = \frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}\left(A_{i,j} - B_{i,j}\right)^2$$

A - Original Image
B - Reconstructed Image
M & N - size of image

2) Compression ratio (CR)

CR=Discarded Data/Original Data

The value lies between $0 \leq CR \leq 1$

The resulting CR can be varied according to the quality of the image and the level of compression depends on the Quantization.

3) Structural Similarity Metric Index (SSIM)

The SSIM index is defined as below:

$$SSIM(A,B) = \frac{(2\mu_A\mu_B + C_1)(2\sigma_{AB} + C_2)}{(\mu_A^2 + \mu_B^2 + C_1)(\sigma_A^2 + \sigma_B^2 + C_2)}$$

A=Original Image
B=Reconstructed Image
μ_A & μ_B – mean intensities of data A & B
σ_A & σ_B –standard deviations of data A& B

If the reconstructed image is exactly similar to original image, then the best value of SSIM index can be achieved which is 1.

$$\sigma_{AB} = \frac{1}{N-1}\sum_{i=1}^{N}(A_i - \mu_A)(B_i - \mu_B)$$

7. PERFORMANCE EVALUATION

Three cases where discussed in this section to evaluate the performance. The evaluated 3 cases are as follows:

Case 1: (Hybrid)

Here only LL coefficients are taken after the first level 2-D DWT decomposition as shown in the block diagram. The idea is shown in figure 6(a).

Case 2: (Sub sampled)

Here along with LL subimage, we take LH & HL sub images of 2nd level decomposition also so that we are adding more high frequency details. So compared to the first case compression ratio will be low her, but the clarity of the output image further increases thereby an increase in PSNR and SSIM values. The idea is shown in figure 6(b).

Case 3: (Fully Sub Sampled)

Here along with the LL, LH & HL subimages of the 2nd level decomposition we take LH & HL sub

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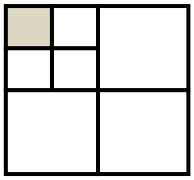
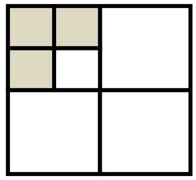
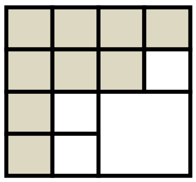
images of 1st level decomposition also. The idea is shown in figure 6(c).



(a)



(b)

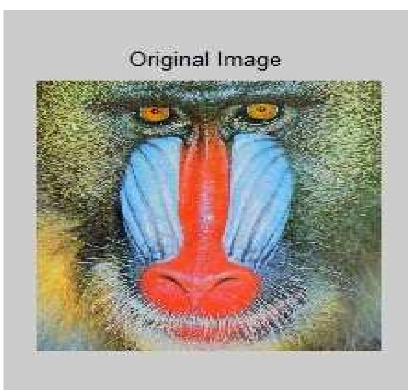


(c)

Figure 6.Three different cases for performance evaluation

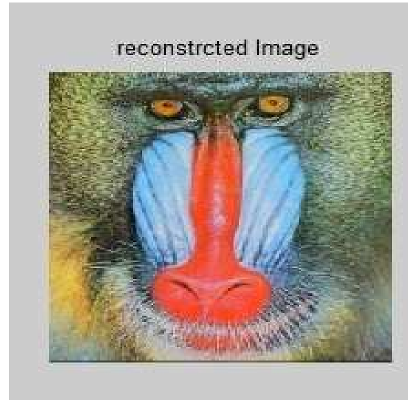
(a) Using Hybrid technique
(b) Using Sub sampled technique
(c) Using Fully Sub Sampled technique

8. OUTPUT IMAGES AND OBSERVATION



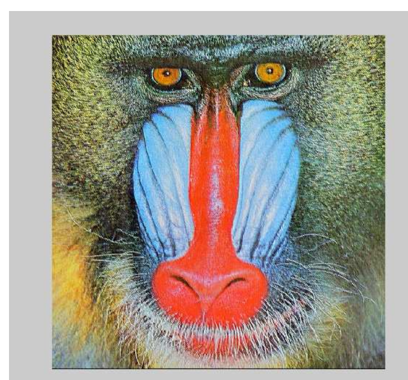
(a) Original image

(b) Hybrid image



(c) Sub sampled image

(d) Fully sampled image



(e) Laplacian Operated Image of figure(d)

Figure 7.Output Images

The performance of all the above cases can be analyzed using the values obtained from PSNR, CR and SSIM which is tabulated below.

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Evaluated results tabulation

Table 1: Shows the PSNR, SSIM and Compression Ratios of the three cases taken

	PSNR	SSIM	CR
Hybrid	**62.8902**	**.8607**	**95.21%**
Sub sampled	**63.1020**	**.8917**	**85.64%**
Fully subsampled	**76.9268**	**.9165**	**56.93%**

From the table we can see while discarding most of the coefficients in Hybrid we can achieve high compression ratio which decreases for other two techniques. On the other hand Full sampled technique gives high PSNR and SSIM compared to sub sampled and Hybrid where Hybrid technique holds less PSNR and SSIM of the three techniques.

9. CONCLUSION

In this paper, we presented a new hybrid DWT-DCT coding scheme that gives high compression ratio without reducing much quality of the image and encoded using arithmetic coding. The new scheme reduces blocking artifacts, ringing effects and false contouring appreciably. The compression ratio that is obtained from this method is more when compared to currently used standards of Image compression, preserving most of the image information.

10. FUTURE SCOPE

For efficient and faster implementation methods like lifting schemes can be introduced for applying DWT and applying adaptive arithmetic coding which is more efficient compared to arithmetic coding. Also this work can be extended by considering the channel effects such as noise, fading etc.

11. ACKNOWLEDGMENT

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REFRENCES:

[1] "Discrete Cosine Transform: Algorithms, Advantages and Applications." by R. K. Rao and P. Yip, NY: Academic, 1990.

[2] "Reducing false contours in quantized color images," by G. Joy and Z. Xiang, Computer and Graphics, Elsevier, vol. 20, no. 2, pp. 231–242, 1996.

[3] "Image compression through wavelet transform coding," by R. A. DeVore, B. Jawerth, and B. J. Lucier, IEEE Transactions on Information Theory, vol. 38, no. 2, pp. 719–746, 1992.

[4]"Wavelets and Filter Banks" by G. Strang and T. Nguyen, Cambridge Press, 1996.

[5] "A hybrid transform technique for video coding," by M. Ezhilarasan & P. Thambidurai, LNCS, vol. 4308, pp. 503–508, 2006.

[6] "Wavelet based hybrid image coding scheme," by T.-H. Yu and S. K. Mitra, in Proc. IEEE Int Circuits and Systems Symp, vol. 1, 1997, pp. 377–380.

[7] "DWT-DCT hybrid scheme for medical image compression," by R. Singh, V. Kumar, and H. K. Verma,Medical Engineering and Technology, vol. 31, pp. 109–122, 2007.

[8] Digital Image Processing 2nd edition by R C Gonzalez and R E Woods, Prentice Hall Publications