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Fundamentals Of Image Compression & Comparative Study Of Relative Study Of JPEG & Hybrid(DWT+DCT) Model

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ABSTRACT— In this paper we have discussed the fundamentals of image compression and compared the results of JPEG and a Hybrid model. In hybrid model we have used DWT (Discrete Wavelet Transform) and DCT (Discrete cosine Transform) for transform mapping. As we know that DWT has its multi resolution property which is helpful for image compression. As in JPEG 2000 also DWT is used but EBCOT (Embedded Block Code for Optimal Truncation) coding has high computational complexity. For JPEG we have taken results for different quality factor values and for hybrid model also we have taken results for different quality factor values and compared it is observed that for very less variation in PSNR value compression ratio has increased considerably.

KEYWORDS—Hybrid Model; EBCOT; JPEG; JPEG2000; PSNR; Compression Ratio

I. INTRODUCTION

Image compression is a technique in that data required to represent an image is reduced by removing the redundancies available in the data. The compression ratio is defined as the ratio of bits required to represent the input image to the bits required to represent compressed Image. If n1 and n2 are the bits required to represent input and compressed image then compression ratio C_R is given by the equation:-

$$C_R = \frac{\text{n1}}{\text{n2}} \quad (1)$$

And the relative data redundancy R_D can be defined as: $R_D = 1 - \frac{1}{C_R}$ (2)

Range of compression ratio and relative redundancy value can vary $(0,\infty)$ and $(-\infty,1)$ respectively[1]. In digital image compression basically three kinds of redundancies can be identified these are coding redundancy, interpixel redundancy, and psycho visual redundancy [1].

Coding redundancy is present when codes assigned to a set of events have not been selected to take advantage of the probabilities of the events. Coding redundancy can be reduced by variable length coding in this process fewer bits are assigned to most probable events than less probable ones to achieve data compression. Average length of code assigned to the various events can be given as:-

$$L_{avg} = \sum_{k=0}^{L-1} l(r_k) p_r(r_k) \quad (3)$$

Where $l(r_k)$ represent bits are required to represent r_k event. So total number of bits required to code an MxN image is MNL_{avg}.

The value of any pixel can be reasonably predicted from the value of its neighbors, the information carried by individual pixel is relatively small. Much of the visual contribution of a single pixel to an image is redundant, it could have been guessed on the basis of values of its neighbor pixel values, and this is called the Interpixel redundancy. In order to reduce interpixel redundancy we transform the values of pixel in another domain that is called mapping.

In an image certain information simply has less relative importance than other information in normal visual processing. This information is said to be psycho visual redundancy. To reduce psycho visual redundancy from the data we use quantization. As quantization is nonreversible process so information lost by this technique cannot be recovered back.

On the basis of information lost during the process of image compression, image compression is of two types. Lossless and Lossy. In lossless compression the original image can be reconstructed back without any loss of data as quantizer is nonreversible so it is avoided in the lossless compression. In lossy compression some amount of data is lost in the process of compression and reconstruction in this we use the quantizer. JPEG, JPEG2000 and Hybrid all are lossy kind of compression technique.

II. JPEG

One of the most popular and comprehensive continuous tone, still frame compression standards is the JPEG standard. In JPEG according to the figure 1 shown standard first color image is read then number of rows and number of columns are made multiple of 8. Then the RGB plane is transformed to YC_bC_r plane by using this relation:

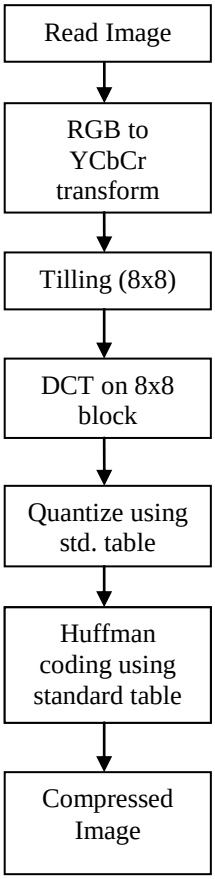

Figure 1-JPEG Compression Flow

$$Y = \left(77/256\right) * R + \left(150/256\right) * G + \left(29/256\right) * B$$

$$C_b = \left(-44/256\right) * R + \left(-87/256\right) * G + \left(131/256\right) * B$$

$$C_r = \left(131/256\right) * R + \left(-110/256\right) * G + \left(-21/256\right) * B$$

Now tilling is done for each plane (YC_bC_r) so we get the 8x8 blocks. On each block DCT is applied to get DCT coefficients the DCT coefficients now quantized using a standard quantization table that is different for every plane and this will be remapped by using a factor called quantization factor we divide the table by quantization factor so that quantization table is modified. Very first coefficient of DCT coefficient block is called the DC coefficient and remaining all is called the AC coefficients. The most of the information remains in DC coefficient and than in low frequency coefficients and then least in high frequency coefficients so we do zigzag coding for the block so that we get a vector of 64 elements DC coefficient is difference coded relative to the DC coefficient of the previous image blocks and for AC coefficients Huffman variable length coding is used [2 3 5]. According to the JPEG standard table AC coding is done. Now we have the compressed image data that can be used to store or to transmit. For JPEG standard the compression ratio varies from 34 to 167 [2].

For decompression the reverse procedure is followed according to the figure 2. Compressed image is first Huffman decoded using JPEG standard entropy coding table. Now this one dimensional vector is reverse zigzag coded to get 8x8 matrix.

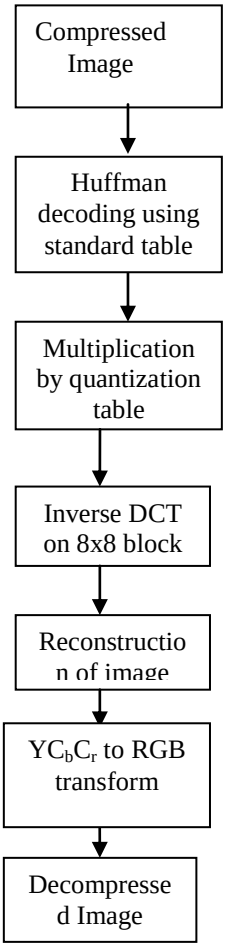

Figure 2-JPEG Reconstruction Flow

Now the matrix is multiplied by the quantization matrix and the inverse 2D-DCT transform is applied on it now we got the image pixel values and these 8x8 blocks are reconstructed to get the full image and the YC_bC_r plane is transformed to standard RGB plane using this relation:-

$$R = Y + 1.371 * (C_r - 128)$$

$B = Y + 1.732 * (C_b - 128)$
$G = Y - 0.698 * (C_r - 128) - 0.336 * (C_b - 128)$

This reconstructed image is approximately identical to the original image with loss of some information.

III. HYBRID MODEL

Hybrid model is like JPEG the only difference is that in this model we have used one level DWT to take advantage multi resolution property of the DWT [6]. JPEG2000 also use the 2D- DWT but due to the EBCOT coding the computational complexity is high [7]. In this model same as JPEG steps are followed figure 3 shows all the steps involved in this model. First we read the image and transform the RGB plane in YC_bC_r plane to de-correlate the values as RGB plane is highly correlated. The same relation is used for the transformation then the image is divided in sub images using tilling process. On each 8x8 block 1 level 2D-DWT is applied [4].

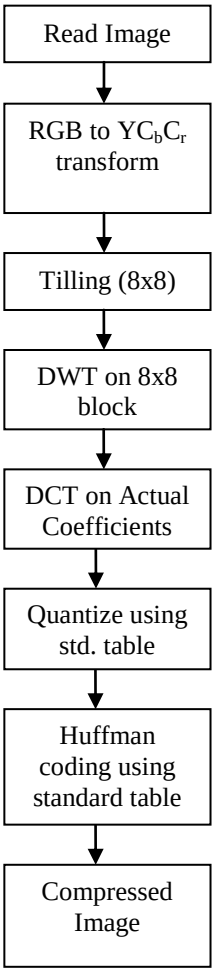

Figure 3-Hybrid Model Compression Flow

This gives two types of coefficients one is Actual and second detailed coefficients. So we take only actual coefficients and apply 2D-DCT on it. Now we have the DCT coefficients so we can use the same quantization table on it as applied in JPEG. So quantization is done by the standard table for JPEG and then this matrix is zigzag coded to get a one dimensional vector and coded using the Huffman variable length coding using its standard table and we get the compression ratio varying from 60 to 210.

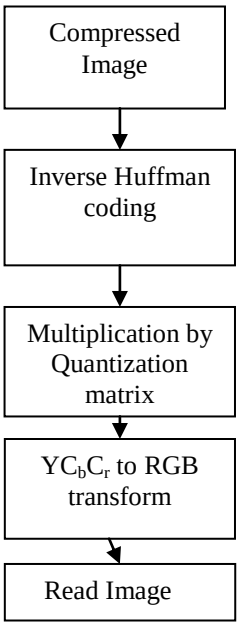

Figure 4-Hybrid model Reconstruction Flow

This is transformed to RGB plane by using the same relation shown in JPEG standard this way we get the reconstructed image. This image is also approximately like original image with loss of some information

IV. RESULTS AND COMPARISON

We show the results get from the JPEG and Hybrid model figure5 show the results from JPEG standard.

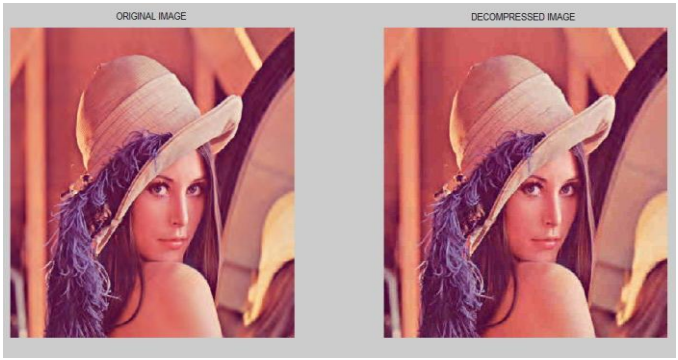

Figure 5-original and Decompressed Image using JPEG

Figure 6-Original and Decompressed image using Hybrid

Figure6 shows the result get from the hybrid model. And figure7 shows the comparative study of JPEG and Hybrid model.

Techniques>		JPEG		Hybrid	
Parameters >	Quality factor	PSNR	C.R.	PSNR	C.R.
Lena(512x512)	0.1	20.64	67.77	24.29	209.72
	0.2	25.10	60.81	27.48	205.12
	0.3	27.57	55.40	28.77	195.13
	0.4	29.09	50.88	29.53	185.58
	0.5	30.08	47.07	29.99	177.52
	0.6	31.00	43.88	30.34	169.43
	0.7	31.69	41.28	30.62	162.19
	0.8	32.21	39.06	30.94	155.17
	0.9	33.15	35.42	31.19	148.52

Table1-Comparison between JPEG and Hybrid

This table involves comparison between JPEG and Hybrid model here we have compared PSNR and compression ratio values of both the models.

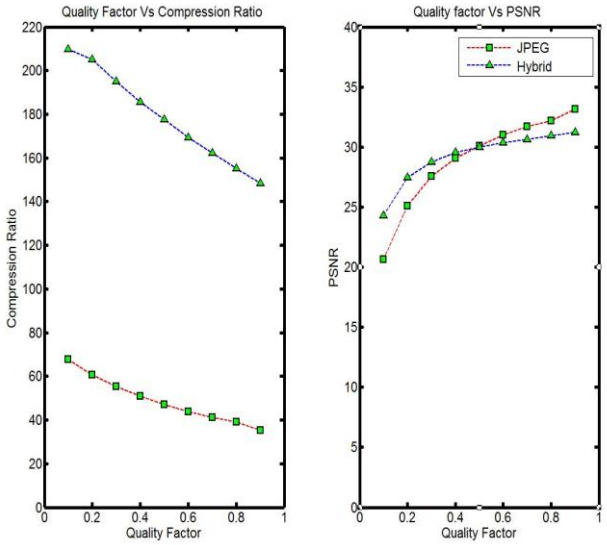

Figure 7-Comparison plots of Compression ratio and PSNR value

V. CONCLUSION

On the basis of results and comparison this can be concluded that on very less variation in PSNR value good compression ratio is achieved. If here additional part that has been added is only the 2D-DWT. At lower quality factor values the PSNR value for hybrid model is better than the JPEG standard and the compression ratio is very high than the JPEG standard. After 0.5 value of the quality factor JPEG overcome the PSNR value but the compression ratio is still very high for hybrid than the JPEG model. So the hybrid model can be used where the high compression ratio is required.

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