Volume 3, No. 1, January 2012

Journal of Global Research in Computer Science

ISSN-2229-371X

RESEARCH PAPER

Available Online at www.jgrcs.info

PERFORMANCE ANALYSIS OF IMAGE COMPRESSION USING DISCRETE COSINE TRANSFORM WITH VARIOUS DISCRETE WAVELET TRANSFORMS

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Abstract: Image compression is a widely discovered area of research & application. Many compression techniques have been developed including few mixed methods. The Discrete Cosine Transform (DCT) is one of the widely used compression method. Also the Discrete Wavelet Transform (DWT) provides substantial improvements in picture quality due to its multi resolution nature. Application of both methods together for image compression can provide a sustained Peak Signal to Noise Ratio (PSNR) along with a better overall compression ratio. This paper aims at the analysis of Color Image compression using DCT and DWT for better PSNR & Compression ratio. A comparative study of performance of DCT & different discrete wavelets is made in terms of Peak signal-to-noise ratio (PSNR), Mean Square Error (MSE) and overall Compression Ratio to illustrate the effectiveness of this method in Image compression. Extensive analysis has been carried out before arrival at the conclusion

INTRODUCTION

Compression of color image is significantly different from the medical image compression. In general purpose compression programs the results are less than optimal. Some of the finer details in the image can be sacrificed for the sake of saving a little more bandwidth or storage space. This is done through lossy compression techniques such as DCT. Uncompressed Image data requires considerable storage capacity and transmission bandwidth. For still image compression, the Discrete Cosine Transform (DCT) is widely accepted standard by `Joint Photographic Experts Group' (JPEG), International Standards Organization (ISO) and International Electro-Technical Commission (IEC). Also the Discrete Wavelet Transform (DWT) has emerged as a cutting edge technology in image compression. DWT provides a better picture quality with selection of appropriate threshold value. A variety of sophisticated wavelets have been developed and implemented in recent years making it a contender for JPEG standards for better compression. As the DCT compression scheme is having simplicity, DWT provides numerous beneficial properties such as embedded coding with progressive transmission and efficient multi-resolution representation, scalability, which are beneficial to the image compression applications [6]. DWTs multi resolution representation matches the Human Visual System, specifically the higher detail information of an image is represented by the shorter basis function with higher spatial resolution and the lower detail information is represented by the larger basis function with higher spectral resolution [16].

In [3] a strategy to increase the compression ratio with simple computational burden and excellent decoded quality is presented for medical image is presented using Hybrid transform. Hybrid transforms leads to increase the compression factor with preserving the quality of image. Also PSNR is improved for specific wavelet transform with increase in compression ratio.

*Error Metrics***:**

Two of the error metrics used to compare the various image compression techniques is the Mean Square Error (MSE) given in equation 1, and the Peak Signal to Noise Ratio (PSNR) to achieve the desirable compression ratios. The MSE is the cumulative squared error between the compressed and the original image, whereas PSNR is a measure of the peak error. A lower value for MSE means lesser error, and as seen from the inverse relation between the MSE and PSNR, this translates to a high value of PSNR. Logically, a higher value of PSNR is good because it means that the ratio of Signal to Noise is higher. Here, the 'signal' is the original image, and the 'noise' is the error in reconstruction.

Mean Square Error (MSE):

Mean square error is a criterion for an estimator: the choice is the one that minimizes the sum of squared errors due to bias and due to variance. The average of the square of the difference between the desired response and the actual system output. In a loss function, MSE is called squared error loss.

$$MSE = {}^{1}/_{mn} \sum_{i=0}^{m-1} \sum_{j=0}^{n-1} \| I(i,j) - K(i,j \text{--------}1$$

Where m and n is the image size and I(i,j) is the input image and K(i,j) is the retrieved image.

Peak Signal-to-Noise Ratio (PSNR):

It is the ratio between the maximum possible power of a signal and the power of the corrupting noise, mathematically given in equation 2. Because many signals have a very wide dynamic range; PSNR is usually expressed in terms of the logarithmic decibel scale. The PSNR is most commonly used as a measure of quality of reconstruction in image compression etc. It is most easily defined via the mean squared error (MSE) which for two m×n monochrome images I and K where one of the images is considered noisy.

$$PSNR = 10.\log_{10}\left(\frac{MAX_I^2}{MSE}\right) = 10.\log_{10}\left(\frac{MAX_I}{\sqrt{MSE}}\right) - -2$$

Here, MAXi is the maximum possible pixel value of the image. When the pixels are represented using 8 bits per sample, this is 255. More generally, when samples are represented using linear PCM with B bits per sample, MAXI is 2B-1.Typical values for the PSNR in Lossy image and video compression are between 30 and 50 dB, where higher is better. PSNR is computed by measuring the pixel difference between the original image and compressed image. Values for PSNR range between infinity for identical images, to 0 for images that have no commonality. PSNR decreases as the compression ratio increases for an image.

PREVIOUS WORK

This method of Hybrid transform has been analyzed for Image data [15]. Also the same has been implemented on Colored Image [1] using Single Wavelet Transform. The Hybrid transform is being implemented on Medical Image [3]

Further this paper is divided into subsections in which image compression which has been done using combination of DCT and DWT by the combination of different wavelets is discussed and appropriate has been shown.

PRESENT WORK

Image Compression Techniques:

Compression using Discrete Cosine Transform:

DCT separates images into parts of different frequencies where less important frequencies are discarded through quantization and important frequencies are used to retrieve the image during decompression. Compared to other input dependent transforms, DCT has many advantages [5]:

a. It has been implemented in single integrated circuit.
b. It has the ability to pack most information in fewest coefficients.
c. It minimizes the block like appearance called blocking artifact that results when boundaries between sub-images become visible.
d. It is widely accepted standard by Joint Photographic Experts Group (JPEG), a standards committee that had its origins within the International Standard Organization (ISO). JPEG provides a compression method that is capable of compressing continuous tone image data with a pixel depth of 6 to 24 bits. JPEG is also capable of producing very high-quality compressed images that are still far smaller than the original uncompressed data.

DCT is primarily a lossy method of compression. It was designed specifically to discard the information that the human eye cannot easily see. Slight changes in color are not perceived well by the human eye, while slight changes in intensity (light and dark) are.

Image Compression using Discrete Wavelet Transform:

Wavelet Transform has also become an important method for image compression. Wavelet based coding provides substantial improvement in picture quality at high compression ratios mainly due to better energy compaction property of wavelet transforms. Wavelet transform partitions a signal into a set of functions called wavelets. Wavelet coding is proving to be very effective technique for image compression giving significantly better results [7], [12]. The standard steps in such compression are to perform the Discrete Wavelet Transform (DWT), quantize the resulting wavelet coefficients and losslessly encode the quantized coefficients as shown in figure 1. These coefficients are usually encoded in raster-scan order, although common variations are to encode each sub-block in a raster-scan order separately or to perform vector quantization within the various sub-blocks. An alternative scheme for encoding wavelet coefficients, termed embedded zero tree coding (EZW), was described by shaprio [6]. Some of the ideas underlying EZW have been significantly modified and enhanced [11]. Wavelet based coding provides substantial improvement in picture quality at high compression ratios mainly due to better energy compaction property of wavelet transforms.

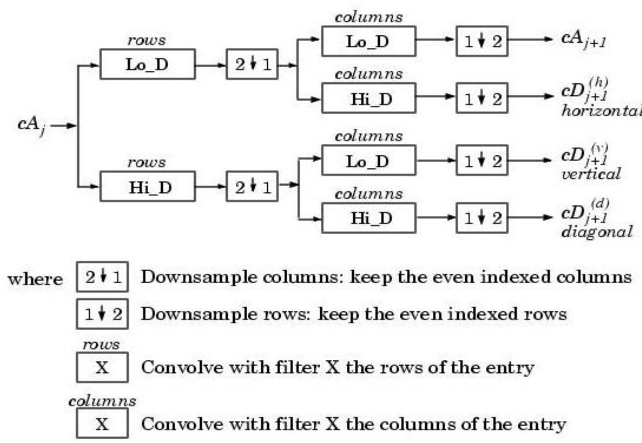

Figure1. Wavelet Coefficient Generation

Hybrid Transform of DCT & DWT is being implemented on Image for Compression. Different Orthogonal Wavelet transforms (Such as Daubechies, Coiflets & BiorSplines) have been used for analysis in terms of MSE & PSNR. As shown in figure 2.

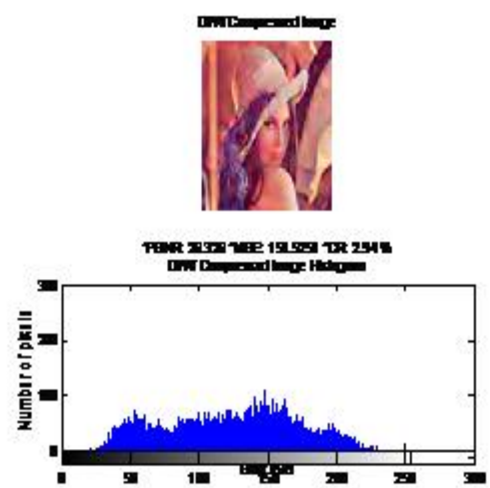

Figure. 2 Lenna Image Compressed with DCT+DWT (bior5.5). PSNR = 26.31 dB, MSE = 151.99, CR = 2.46 %

Here in figure 2 wavelet used is bior5.5. by which compression ratio obtained is 2.46%.

Similarly this image is used for the representation assumed technique for image compression and decompression with combination of CT and DWT with different type of wavelets and all the result of this is shown in the next section.

RESULTS

Here in this section the final results obtained after applying hybrid combination of DCT and different wavelets is represented below in the tabular form. Table1 includes the compression ratio of the image under process for different wavelets at fixed CR of DCT.

Table 1. Overall Compression Ratio %

DCT (CR%)	10	20	30	40	50
bior1.1	12.62	22.33	32.04	41.73	51.44
bior3.1	12.65	22.36	32.06	41.76	51.46
bior5.5	12.21	21.97	31.75	41.49	51.26
coif1	12.52	22.23	31.97	41.69	51.41
coif3	12.62	22.32	32.02	41.74	51.45
coif5	12.45	22.18	31.91	41.66	51.37
db1	12.62	22.33	32.04	41.73	51.44
db3	12.39	22.11	31.86	41.59	51.33
db5	12.46	22.18	31.92	41.65	51.38

Table 2. Overall Peak Signal to Noise Ratio (dB)

DCT(CR%)	10	20	30	40	50
coif5	28.49	28.43	28.30	28.10	27.72
coif3	28.03	27.96	27.85	27.77	27.43
bior5.5	26.59	26.63	26.61	26.48	26.29
db5	27.76	27.73	27.64	27.43	27.08
bior3.1	26.33	26.27	26.33	26.41	26.28
db3	27.87	27.84	27.72	27.54	27.19
coif1	27.58	27.52	27.41	27.35	27.04
bior1.1	26.78	26.73	26.66	26.55	26.20
db1	26.78	26.73	26.66	26.55	26.20

Table 3. Overall Mean Square Error

DCT(CR%)	10	20	30	40	50
coif5	92.10	93.28	96.16	100.71	109.87
coif3	102.34	103.91	106.52	108.57	117.48
db3	106.22	107.05	109.98	114.60	124.33
db5	108.79	109.61	112.07	117.40	127.43
coif1	113.48	115.22	118.10	119.72	128.69
bior1.1	136.34	138.19	140.35	144.01	155.92
db1	136.34	138.19	140.35	144.01	155.92
bior5.5	142.62	141.20	141.96	146.21	152.72
bior3.1	151.53	153.63	151.41	148.62	153.18

Table 2 and Table 3 represent the PSNR and MSE after applying Hybrid combination of DCT and DWT.

CONCLUSIONS & FUTURE WORK

It is being observed from the analysis that the PSNR of the Hybrid transform increase with increase in overall compression ratio such as for DWT (bior3.1) PSNR = 26.31dB with compression ratio of 2.76%, And when hybrid transform is used with DCT, it increases to 26.33dB. Therefore for 10% DCT compression ratio DWT can be implemented using bior3.1 wavelet to obtain better compression ratio & PSN. But this quality does not retain for all DCT compression levels. In future, more wavelets can be analyzed for improvement in PSNR, MSE & overall compression ratio

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