# A Review on Image Compression using DCT and DWT

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*Abstract*— Image Compression addresses the matter of reducing the amount of data needed to represent the digital image. There are several transformation techniques used for data compression. Discrete Cosine Transform (DCT) and Discrete Wavelet Transform (DWT) is mostly used transformation. The Discrete cosine transform (DCT) is a method for transform an image from spatial domain to frequency domain. DCT has high energy compaction property and requires less computational resources. On the other hand, DWT is multi resolution transformation. The research paper includes various approaches that have been used by different researchers for Image Compression. The analysis has been carried out in terms of performance parameters Peak signal to noise ratio, Bit error rate, Compression ratio, Mean square error. and time taken for decomposition and reconstruction.

***Key words:*** Compression, DCT, DWT, MSE, SNR, PSNR

## I. INTRODUCTION

An image can be defined as a matrix of pixel or intensity values. Image compression is used to reduce the redundancy and randomness present in the image because to increase the storing capacity and efficiency level of the images. Therefore it is essential to compress the images by storing only the required information needed to reconstruct the image. To compress any image, redundancy must be removed. Sometimes images having large areas of same color will have large redundancies and similarly images that have frequent and large changes in color will be less redundant and harder to compress.

## II. FUNDAMENTALS OF IMAGE COMPRESSION TECHNIQUES

A digital image, or "bitmap", consists of a grid of dots, or "pixels", with each pixel defined by a numeric value that represents its colour. A Typical characteristic of most images is that the neighboring pixels are correlated and therefore contain redundant information. The foremost task then is to find less correlated representation of the image. In general, there are three types of redundancy:

### *A. Coding Redundancy*

Use smaller code words for the commonly used gray levels and longer code words for the less commonly used gray levels. This is an example of Variable Length Coding. To reduce coding redundancy from an image we use Huffman technique where we assign fewer bits to the more probable gray levels than to the less probable ones to achieve sufficient data compression[10]

### *B. Inter Pixel Redundancy*

Another important type of data redundancy is inter pixel redundancy, which is directly related to the inter pixel correlations within an image. Because the value for any given pixel can be reasonable predicted from the value of its neighbours, the information carried by individual pixels 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 its neighbor's values. A variety of names, including spatial redundancy, geometric redundancy, and inter frame Redundancies have been given to refer to these inter pixel dependencies.[10]

### *C. Psycho Visual Redundancy*

Human perception of the information in an image normally doesn't involve quantitative analysis of every pixel or luminance value in the image. In general, an observer searches for distinguishing features such as edges or textural regions and mentally combines them into recognizable groupings. The brain then correlates these groupings with prior knowledge in order to complete the image interpretation process. So eye doesn't respond with equal sensitivity to all visual information. Certain information simply has less relative importance than other information in normal visual processing. This information is called psycho visually redundant. To reduce psycho visual redundancy quantizer is used. Therefore, the elimination of psycho visually redundant.[10]

## III. WHAT ARE THE DIFFERENT CLASSES OF COMPRESSION TECHNIQUES?

Two ways of classifying compression techniques are mentioned here.

### *A. Lossless vs. Lossy compression*

In lossless compression schemes, After compression the reconstructed image is numerically identical to the original image. However lossless compression can only achieve a modest amount of compression. In lossy compression An image reconstructed is degraded relative to the original. This is because lossy compression scheme completely discards redundant information. However, lossy schemes are capable of achieving much higher data compression. Under normal viewing conditions, no visible loss is perceived (visually lossless).

### *B. Predictive vs. Transform coding*

In predictive coding, information already available or sent is used to predict future values, and the difference is coded. Since this is done in the image or spatial domain, it is relatively simple to implement and is readily adapted to local image characteristics. Differential Pulse Code Modulation (DPCM) is an example of predictive coding[4]. Transform coding, on the other hand, first transforms the image from its spatial domain representation to a different type of representation using transformation techniques and then codes the transformed values (coefficients). This method provides greater data compression compared to predictive methods, although at the expense of greater computation.

## IV. VARIOUS COMPRESSION TECHNIQUES

### A. *DCT-Based Image Coding Standard*

Discrete Cosine Transform (DCT) exploits cosine functions, it transform a signal from spatial representation into frequency domain. The DCT represents an image as a sum of sinusoids of varying magnitudes and frequencies. DCT has the property that, for a typical image most of the visually significant information about an image is concentrated in just few coefficients of DCT .

#### 1) *Forward DCT*

$$F(u,v)=\frac{2}{N}C(u)C(v)\sum_{x=0}^{N-1}\sum_{y=0}^{N-1} f(x,y)\cos\left[\frac{\pi(2x+1)u}{2N}\right]\cos\left[\frac{\pi(2y+1)v}{2N}\right]$$

for $u=0,\ldots,N-1$ and $v=0,\ldots,N-1$

where $N=8$ and $C(k)=\begin{cases}1/\sqrt{2} & \text{for } k=0\\ 1 & \text{otherwise}\end{cases}$

#### 2) *Inverse DCT:*

$$f(x,y)=\frac{2}{N}\sum_{u=0}^{N-1}\sum_{v=0}^{N-1} C(u)C(v)F(u,v)\cos\left[\frac{\pi(2x+1)u}{2N}\right]\cos\left[\frac{\pi(2y+1)v}{2N}\right]$$

for $x=0,\ldots,N-1$ and $y=0,\ldots,N-1$ where $N=8$

Nageswara Rao Thota et al. (2008) [3] proposes Image Compression Using Discrete Cosine Transform. DCT images are divided into blocks of 8x8 or 16x16 or bigger. The problem with these blocks is that when the image is reduced to higher compression ratios, these blocks become visible One of the main problems and the limitation of the DCT is the blocking effect. The following table1 shows the test reports in the image compression using DCT

| Test case no | Input | Expected Behavior | Observed Behavior | StatusP = Passed F = Failed |
|---|---|---|---|---|
| 1 | Input image of size 128x128 | Input image is converted into class double | -Do- | P |
| 2 | Input image with double class | Converting the pixel values to zeroes | -Do- | P |
| 3 | 128x128 image with zero pixel values | 128x128 image converted into 8x8 Matrix image | -Do- | P |
| 4 | 8x8 Block image | 8x8 DCT image | -Do- | P |
| 5 | Applying quantization on 8x8 DCT image | We obtain frequency coefficients | -DO- | P |
| 6 | Applying zig zag scan to the frequency coefficients | Sorting the frequency coefficients from lower to higher | -DO- | P |
| 7 | Applying DPCM on DC components | Encoding the difference from previous 8x8 blocks DPCM | -Do- | P |
| 8 | Applying RLE on AC components | Skipping the zero value components | -DO- | P |

The following table1 shows the test reports in the image compression using DCT

Maneesha Gupta et al. ( 2012) [5] proposes some simple functions to compute the DCT and to compress images. Image Compression is studied using 2-D DCT. The original image is transformed in 8-by-8 blocks and then inverse transformed in 8-by-8 blocks to form the reconstructed image. The inverse DCT would be performed using the subset of DCT coefficients. The error image (the difference between the original and reconstructed image) would be displayed. The results shows that DCT exploits inter pixel redundancies to render excellent decorrelation for most natural images. Therefore all transform coefficients can be encoded independently without compromising coding efficiency. In addition, the DCT packs energy in the low frequency coefficients. Therefore, some of the high frequency coefficients can be discarded without degradation in image quality.

### B. *Image Compression by Wavelet Transform:*

A "wavelet" mathematical function is used to divide a given function or continuous-time signal into different wave signals. It is the delegation of a function by wavelets. The Haar wavelet is the simplest wavelet. The limitation of the Haar wavelet is that it is not continuous, and therefore not differentiable. The Haar wavelet's mother wavelet function $\psi(t)$ can be described as

$$\psi(t)=\begin{cases}1 & 0\le t<1/2,\\ -1 & 1/2\le t<1,\\ 0 & \text{otherwise.}\end{cases}$$

and its scaling function $\varphi(t)$ can be described as

$$\phi(t)=\begin{cases}1 & 0\le t<1,\\ 0 & \text{otherwise.}\end{cases}$$

Sonja Grgic, et al. (2009) [6] proposes a set of wavelet functions (wavelets) for implementation in image compression system and to highlight the benefit of this transform relating to new methods. The consequences of different wavelet functions, image contents and compression ratios are assessed. A comparison with a discrete-cosine-transform-based compression system is given. The final choice of optimal wavelet in image compression application depends on image quality and computational complexity.

Amina Khatun et al. (2012) [7] have proposed the new image compression scheme with pruning based on discrete wavelet transformation (DWT). The effectiveness of the algorithm has been justified over some real images, and the performance of the algorithm has been compared with different common compression standards. Experimental results demonstrate that the proposed technique provides sufficient high compression ratios compared to different compression techniques. A new image compression scheme based on discrete wavelet transform is proposed which provides high compression ratios with no considerable degradation of image quality. The effectiveness and robustness of this approach has been justified using a set of real images. To demonstrate the performance of the proposed method, a comparison between the proposed technique and other common compression techniques has been revealed. From the experimental results it is evident that, the proposed compression technique gives better performance compared to other traditional techniques. Both DCT and DWT are very popular compression techniques for colour and grey level images. There are many flavours in each technique. In this a hybridised form of the techniques are implemented for compressing images.

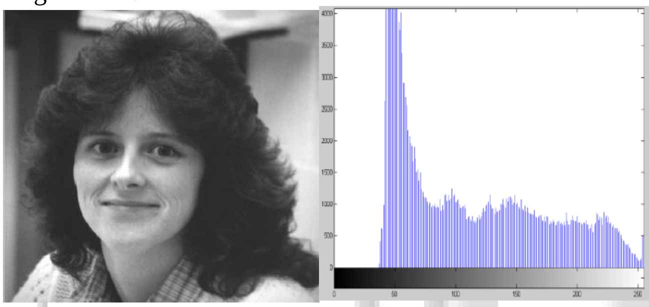
Aisha Fernandes, Wilson Jeberson et al(2014)[11] proposes wavelet transform and the Antonini 7/9 filter [5] for compressing an image. It is thus seen that images compressed decompressed using the proposed wavelet based compression algorithm (WCP) produces consistently better images and a higher PSNR (Peak signal to noise ratio) than the jpeg compression algorithm at the same compression percentage.

(a) (b) (c)

Fig. 1: Comparison of visual image quality for the test image cameraman.bmp at a compression ratio of 9:1. (a) Original image (b) wcp compressed image (c) Jpeg compressed image.

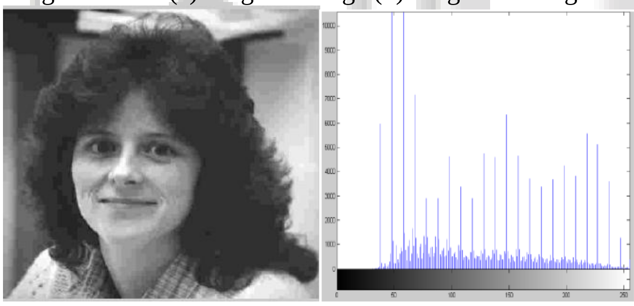
### *C. Hybridised DCT and DWT Compression*

Prabhakar.Telagarapu, A.Lakshmi.Prasanthi, G.Vijaya Santhi, V.Jagan Naveen et al (2011)[1] proposes an DCT and DWT for image compression and decompression. By taking several images as inputs, it is observed that Mean Square Error is low and Peak Signal to Noise Ratio is high in DWT than DCT based compression. From the results it is concluded that on the basis of compression ratio overall performance of DWT is better than DCT. In Discrete Cosine Transform image need to be "blocked", correlation is found across the block boundaries which can't eliminated which results in noticeable and annoying, blocking artifacts" particularly at low bit rates. Wavelets are good to represent the point singularities and it cannot represent line singularities.



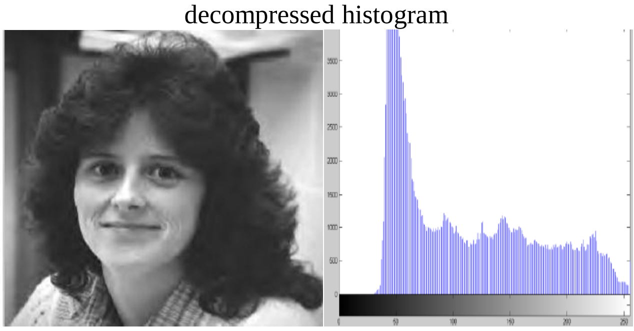
(a) (b)

Fig. 2: shows (a) Original Image (b) Original Histogram



(a) (b)

Fig 3: shows (a) DCT decompressed image (b) DCT decompressed histogram



(a) (b)

Fig. 4: shows (a) DWT decompressed image (b) DWT decompressed histogram

Vellaiappan Elamaran et al. (2012) [2] proposes a Comparison of DCT and Wavelets in Image coding. Fourier based transforms (e.g. DCT and DFT) are efficient in exploiting the low frequency nature of an image. The high frequency coefficients are coarsely quantized, and therefore the reconstructed image at the edges will have poor quality. On the other hand, wavelets are efficient in representing non stationary signals because of the adaptive time-frequency window. So the Discrete Wavelet Transform (DWT) is applied in an image and the PSNR of both DCT and DWT is compared. A comparison and analysis and of image compression using DCT and DWT is demonstrated. K.Saraswathy et al. (2013) [4] have proposes an orthogonal approximation for the 8 point Discrete Cosine Transform (DCT). The proposed transformation matrix contains only ones and zeros. Bit shift operations and multiplication operations are absent. The approximate transform of DCT is obtained to meet the low complexity requirements. The hybrid results obtained from the work will shows clearly the efficiency of the proposed transform in image compression. Finally, the new approximation offers the users another options for mathematical analysis and circuit implementations. The new approximate transform matrix has rows constructed from a different mathematical structure when compared to DCT. These rows can be considered in the design of hybrid algorithm which take advantage of the best matrix rows from the existing algorithm aiming at novel improved approximate transform.

According to Author Ch.Sathi Raju and D.V.Rama Koti Reddy et al (2015) [12] Compression is a serious problem in capsule endoscopy applications. It dictates the power consumption characteristics and the capsule life. In this paper a hybrid DCT and DWT compression method is employed to capitalise the advantages of both the techniques. It involves in applying a three level DWT on the input image. The DWT compressed image is taken for quantization and further zeros are eliminated from the matrices. Further is subjected to compression using arithmetic coding(AC). Now 1D DCT is applied to the LL3 image and followed by the process of quantization and eliminating zeros and applying arithmetic coding is repeated for satisfactory compression. The color data is extracted from the compressed image. This color data is further serves as input to the decompression section. The decompression process is simply reverse to the compression process. The results pertaining to the simulated experiment are presented in this section. Lena images are considered initially and the proposed technique is applied on it. The corresponding original and decompressed images are presented in Fig.5

(a) (b)

Fig. 5: 'Lena' image (a) Original and (b) decompressed

## V. CONCLUSION AND FUTURE WORK

This paper represents the concept of compression and varied technologies used in the image compression comparing the performance of compression technique identical data sets and performance measure are used. In this paper comparative analysis of varied Image compression techniques for different images is done based parameters mean square error (MSE), peak signal to noise ratio (PSNR). DWT produces higher results without losing more information of image. Pitfall of DWT is, it requires more processing power. DCT overcomes this disadvantage since it needs less processing power, but it produces less compression ratio. DCT based standard JPEG uses blocks of image. In wavelet, there is no need to block the image.

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