

Improving Reconstructed Image Quality via Hybrid Compression Techniques

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Received: 19 September 2020; Accepted: 27 October 2020

Abstract: Data compression is one of the core fields of study for applications of image and video processing. The raw data to be transmitted consumes large bandwidth and requires huge storage space as a result, it is desirable to represent the information in the data with considerably fewer bits by the mean of data compression techniques, the data must be reconstituted very similarly to the initial form. In this paper, a hybrid compression based on Discrete Cosine Transform (DCT), Discrete Wavelet Transform (DWT) is used to enhance the quality of the reconstructed image. These techniques are followed by entropy encoding such as Huffman coding to give additional compression. Huffman coding is optimal prefix code because of its implementation is more simple, faster, and easier than other codes. It needs less execution time and it is the shortest average length and the measurements for analysis are based upon Compression Ratio, Mean Square Error (MSE), and Peak Signal to Noise Ratio (PSNR). We applied a hybrid algorithm on (DWT–DCT 2×2 , 4×4 , 8×8 , 16×16 , 32×32) blocks. Finally, we show that by using a hybrid (DWT–DCT) compression technique, the PSNR is reconstructed for the image by using the proposed hybrid algorithm (DWT–DCT 8×8 block) is quite high than DCT.

Keywords: Image compression; discrete cosine transform; PSNR; discrete wavelet transform; hybrid algorithm

1 Introduction

For image compression, transform-based compression demonstrates greater robustness than spatial domain-based compression. The compression technique may be either lossless or loose. The compression ratio of data loss, however, is very high, but it suffers from lossy compression. Yet this is a high compression ratio, really.

In the lossless compression method, the decompressed image is identical to the original one, but with the compression ratio [1].



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DCT cosine transforms the image from the space domain to the frequency domain, where the top left corner of the DCT matrix coefficient is the low-frequency component, and the frequency from the top left corner is decreased diagonally [2].

Discrete wavelet converts the image into four separate frequency bands called LL, LH, HL, and HH, where image characteristics are reflected by LL sub-bands and signal noise is shown by HH sub-bands [3].

The DCT algorithm shows better energy compaction features and requires fewer computational difficulties. This removes the blocking artifact and the misleading contouring results, though DWT, it is a multi-resolution compression process but DWT's feature of energy compaction is less and induces a ringing effect.

In this paper, the transformation techniques chosen for image compression include discrete cosine transformation (DCT) and discrete wavelet transformation (DWT). The DCT transform is used in image coding (JPEG).

2 Transformation Techniques

2.1 Discrete Cosine Transform

DCT is an orthogonal transformation that is used for decorrelating image data. Encoding each transform coefficient is easy after using DCT without losing compression efficiency.

The quantization table option influences the compression ratio and entropy. In a lossy compression algorithm, the process of quantization is referred to throughout a stage.

The 2-D DCT is specified in Eq. (1):

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

For $u = 0, \dots, N - 1$ and $v = 0, \dots, N - 1$

Coding Scheme

Compression Process

First of all, the whole image is loaded into the encoder, then transformed from RGB to YCBCR. The entire image is then divided into tiny NXN image blocks. From top to bottom or left to right, there are two directions where every block is applied to the DCT.

By dividing each transformed data item by the corresponding pixel in the quantization matrix Q, and rounding it to the nearest integer value, as shown in Eq. 2, the recompressed components of each block are obtained.

$$F(u, v)_{Quantization} = \text{round} \left[\frac{F(u, v)}{Q(u, v)} \right] \quad (2)$$

The 1D array is extracted and transmitted to the receiver from this the encoding process is completed [4]. Extra compression can be achieved by applying acceptable entropy encoding. The de-quantized matrix is displayed in Eq. 3 and then using the 2-D inverse DCT.

$$F(u, v)_{deQ} = F(u, v)_{Quantization} \times Q(u, v) \quad (3)$$

Decompression Procedure

The image reconstruction, the quantified DCT coefficients, are decoded and the inverse 2DDCT of the computer block is computed, then the blocks are collected in one image together. There are two important steps in this decoding process when applying the dequantization matrix to blocks: Maintaining the size of the block equals that used in the encoding method.

2.2 Discrete Wavelet Transform

For turning the coordinate system, wavelets are “a mathematical tool.” For applications where tolerable degradation and scalability are significant, they are suitable.

Multiresolution Concept and Analysis

The representation of signals is designed by the multi-resolution concept When a single occurrence is broken down into smaller, smaller specifics [5,6].

Filter Bank

It is a collection of filters. Synthesis and analysis banks are components of it. It is represented in Fig. 1



Figure 1: Filter bank

Analysis Bank

It has two filters: A high and a low pass [6]. HH, LH, LL, and HL are four bands that are produced from this passing. Those 4 bands are the decomposition’s first level. Fig. 2 illustrated finer scale and coarser scale wavelet coefficients.

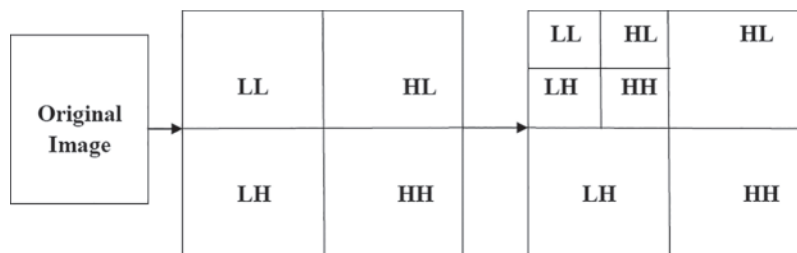


Figure 2: Wavelet coefficients finer and coarser scale

Synthesis Bank

That is the reverse of analytics bank collection. This included filtration and decimation.

Coding Scheme

Compression Process

Passing image through LPF and HPF and the Output from it is $A1 = [L1, H1]$.

Then A1 is passed over again by HPF and LPF by adding a filter to each board. The performance of [L2 and H2] is $A2=$. Now A2 is sampled down by 2 to cause a compressed image.

Through taking the actions above we can do more than one degree [7].

Decompression Process

By actually taking a higher half matrix rectangle, extracting LPF and HPF images from compressed images are an LPF image and half a rectangle down is an HPF image.

Then the two images are summed up by 2. Actually, the sum of both images is taken into 1 image named B1.

Then, by vertically splitting [8], separate the LPF picture and the HPF image. The two halves obtained are filtered through LPF and HPF, providing the reconstructed image on each block of 32×32 blocks, summing up these halves.

In [Tab. 1](#) illustrated the advantages and disadvantages of DCT and DWT.

Table 1: The advantages and disadvantages of DCT and DWT

	DCT	DWT
Advantages	Packing the most important information in little space of coefficients. It lessens the blocking artifact effect.	Permitting image multiresolution representation. Permitting progressive transmission
Disadvantages	Blocking artifacts: Is a distortion that appears as an abnormally large pixel block, due to heavy compression. False contouring: Occurs when the graded area of the image is smoothly distorted by a deviation that looks like a contour map for specific images with gradually shaded areas.	Memory intensive. Time-consuming.

3 Related Works

3.1 Image Compression Using DCT

This section shows some previous researcher's studies for image compression using the DCT method.

Douak et al. [9] combined DCT transform with an adaptive block scanning to compress the color image in some steps. The first step is done by conversing from RGB color space to YCbCr color space and then using the DCT transform.

Using the Bisection technique, an iterative phase involving thresholding and quantization process was done to compress an image. Reconstructing the original image was done in the reverse process. The results explain that the system was efficient and was compared to a block truncation-based coder. The proposed method's (M-3) PSNR higher than that of JPEG by approximately 2.22 db.

Khalil [10], suggested an entropy coder for the encoding of images based on the Discrete Cosine transformation. The proposed idea is to remove the consecutive non-zero coefficients in each 8×8 block which precede the zero coefficients. In the run-length decoder, the output is the number of coefficients of none-zero and then the coefficients themselves for each block. The

method of decompression should be developed frequently. The findings of the simulation reveal that the new technique has a higher compression ratio than the previous form of entropy coding called the run process.

Chen et al. [11], proposed a modern paradigm incorporating the classical local DCT used in image compression algorithms with a regional noiseless calculation which is solved using second-order cone programming. The first step in the algorithm is to transfer DCT knowledge that is appropriate for reproducing poor-resolution image quality deterioration relative to survival, but the constraint is poor image quality.

Pandit et al. [12] proposed an efficient image compression approach depended on JPEG image compression. The objective of this research is to find the relation between image quality and compression mount. The results show that for images of size between 3 to 5 MB, the best results are got at quantization factor ranging from 25% to 30% where 80% to 85% compression can be found.

Pandey et al. [13] proposed the image compression techniques using the DCT method with different blocks and quantization methods for reducing the blocking artifacts in reconstruction images. The proposed method is subdivided into blocks (4×4 , 8×8 , 16×16 , and 32×32) and the maximum image dimension is divided into a maximum block size & compressed the image. The performance between the original and reconstructed images is analyzed using several images and calculated with various quantization matrices with a PSNR score. From the results, it is found that when the maximum value is given by the quantization matrix then the restored image is distorted as its MSE value decreases.

Abd-Elhafiez et al. [14], the proposed compression technique is performed by RGB to YCbCr color transformation process. Second, canny edge detection is used to distinguish blocks into the edge and non-edge blocks. Using adaptive arithmetic coding, each Y, Cb, and Cr color variable is compressed, quantized, and coded by (DCT) method.

3.2 Image Compression Using DWT

This section presents the previous researcher's studies for image compression using DWT and hybrid techniques.

Chowdhury et al. [15] proposed an image compression process with a pruning proposal depended on the basic DWT technique. The steps of the proposed compression algorithm are choosing a wavelet level, the hard threshold is applied to the detail coefficients, reconstruct the image. This algorithm supplied sufficient high compression ratios with good image quality.

Khan [16] presented several image segmentation methods, upon studying various image segmentation techniques, it is proposed that the easiest approach to solving the image segmentation problem is a hybrid method for image segmentation composed of two or more techniques.

Sathik et al. [17] proposed the hybrid image compression technique and this hybrid technique segments the image into foreground and background regions based on edges. Then the regions compressed with various quality levels. This hybrid method provides the compression ratio and gives a desired quality compressed image.

Benchikh et al. [18], a hybrid DCT–DWT image compression solution was proposed to optimize the effects of both the DCT and DWT techniques. They have shown that, where several coefficients used for image restoration are small, DWT yields a better PSNR in image compression than DCT.

Elharar et al. [19], presented a compression method developed for the specific features of the digitally registered integral image.

The compression algorithm is based on a hybrid methodology that applies a four-dimensional transformation that incorporates the discrete wavelet transformation with the discrete cosine transformation. an earlier compression method developed for MPEG integral image-based image.

Agrwal et al. [20], presented the compression technique Hybrid Integer Wavelet Transform (IWT) and Discrete Cosine Transform (DCT) to achieve better-decompressed image output relative to compression technique DWT + DCT.

The proposed IWT + DCT-based hybrid compression technique reduces fractional loss relative to DWT-based compression, meaning that the proposed technique improves the image quality of decompression image with a high compression ratio comparable to DWT-based, and hybrid DWT DCT-based data compression techniques.

4 Proposed Framework for Color Images Compression Techniques

Hybrid of (DWT + DCT) transform lessens ringing effect, blocking artifacts, and false contouring. For every color image, each of the new three planes (Y, Cb, Cr) is partitioned into blocks after the preprocessing phase (RGB to YCbCr).

The various sizes (2×2 , 4×4 , 8×8 , 16×16 , or 32×32) were tested. Every block is translated to DWT and transferred to DCT after that.

Coding Scheme

In the Compression process, the input image is first converted from RGB to YCbCr, when this whole image is broken into blocks of 32×32 pixels. Four details (LL, HL, LH, and HH) are produced after stratifying 2 D-DWT. The sub-band (LL) by 2 D-DWT is further transformed. The process continues until to get a new set of four sub-bands of size 8×8 . After this step, we use the LL2 sub-band for computation of DCT coefficients. The output of it is then quantized and sends for coding using Huffman encoding. The other bands (HL2, LH2, and HH2) are quantized and encoded by Huffman. Fig. 3 illustrated the complete coding scheme.

In the decompression process, all the reversed processes are performed in the decompression method. We decipher the quantized DCT coefficients and measure each block's IDCT. Block is then quantized.

5 Implementation of Color Image Compression Hybrid Techniques (DWT-DCT)

This section assesses the efficiency of various compression techniques for images. The hybrid techniques are applied to some color images. The results of (DCT, DWT) techniques, hybrid technique (DWT-DCT).

Simulation Tool

The proposed techniques were implemented using MATLAB and the evaluation parameters are CR, PSNR, and MSE.

Fig. 5 shows the reconstructed Pepper image using DCT, DWT, hybrid (DWT-DCT). Tab. 2 shows a comparison between compression techniques on Pepper image using evaluation parameters. Fig. 4 shows a chart for PSNR of different compression techniques for Pepper image.

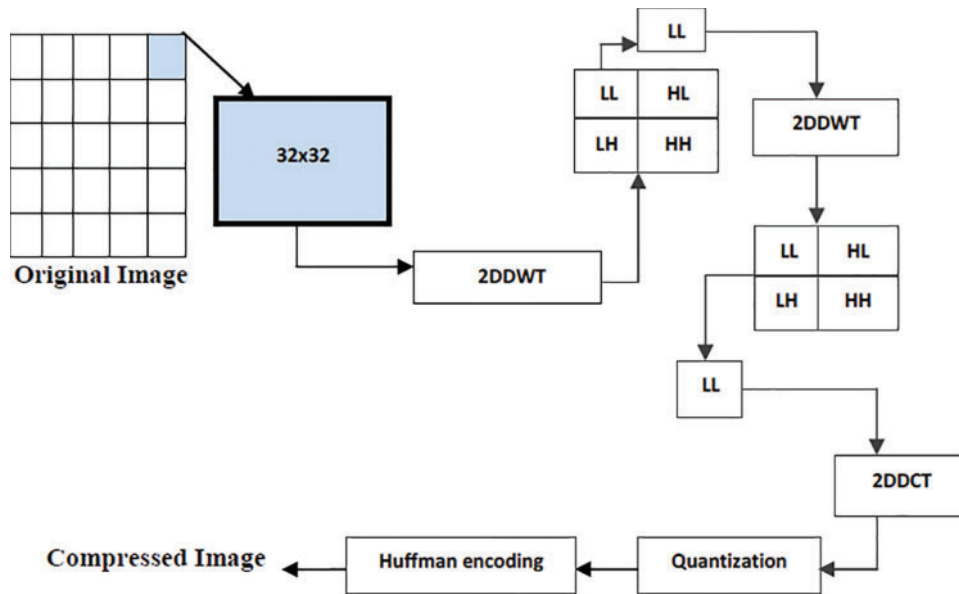


Figure 3: Compression process using hybrid DWT-DCT

Table 2: Comparison between compression techniques on Pepper image

Technique	CR	MSE	PSNR
DCT	19.555	10.718	37.829
DWT	12.195	16.85	34.669
(DWT-DCT 2 × 2)	2.5270	10.3068	37.9996
(DWT-DCT 4 × 4)	2.4854	10.1201	38.0790
(DWT-DCT 8 × 8)	2.5340	10.1872	38.0503
(DWT-DCT 16 × 16)	2.6233	10.2542	38.0218
(DWT-DCT 32 × 32)	2.7007	10.2303	38.0319

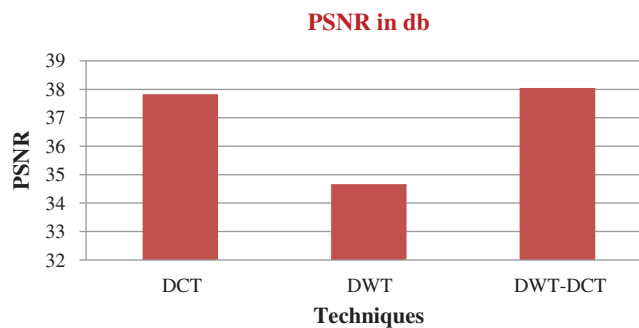


Figure 4: PSNR for pepper image of different techniques



Figure 5: The reconstructed Pepper image from techniques

From [Tab. 2](#) and [Fig. 6](#), we find that better PSNR than DWT is provided when the image is reconstructed using DCT, and the visual quality of the reconstructed image is better using DCT. The PSNR for the image that is reconstructed using the proposed hybrid algorithm (DWT–DCT 8×8 block) is quite high than DCT and DWT.

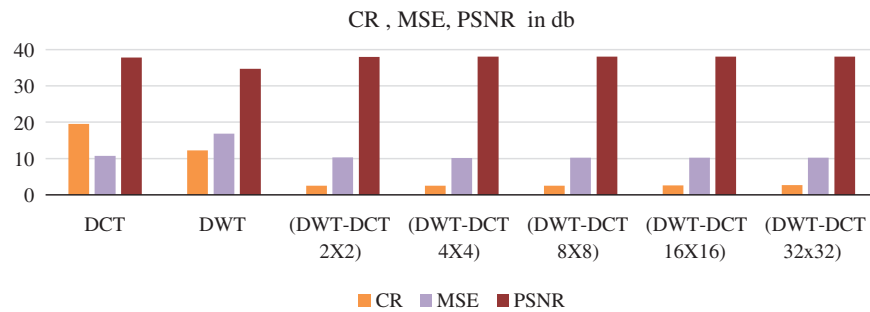


Figure 6: CR, MSE, PSNR for pepper image of different techniques

6 Conclusion

In this paper, the image compression techniques were analyzed by using the objective (PSNR, CR, and MSE) and subjective evaluation factors. Centered on the effects of the analysis set out above. For images, the suggested hybrid DWT–DCT algorithm can be shown to outperform the DCT and Daubechies-based DWT techniques. This is found that the restored images tend to be the strongest in the case of the DWT method, but with the DCT they are distorted by errors and incorrect contouring results.

The hybrid algorithm proposed has consistently higher PSNR and better quality for reconstruction.

It may also raise the impact of inaccurate contouring and images artifacts.

Funding Statement: The authors received no specific funding for this study.

Conflicts of Interest: The authors declare that they have no conflicts of interest to report regarding the present study.

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