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Combinations of DCT & DWT approach using Run Length Coding in Wavelet Image Compression

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Abstract - **The proposed method implements using lossy grayscale image compression techniques. So, that the compressed image preserves its quality. This approach combines the DCT & DWT scheme with the Run Length Coding technique to lessen the compression ratio of non-zero elements in the compressed image. The Original image is divided into 8×8 non overlapping block size then apply the combination of DCT & DWT Wavelet Based Run Length Coding (WRLC) to produces the good compression rate in Lena image is 1.29 KB and the Cameraman image produces the compression rate is 1.27 KB.**

Keywords —Lossy Compression, Run Length Coding, MSE, PSNR and CR

I. INTRODUCTION

The development of the new technology is entering into the Digital Phase; the world has created virtually during an enormous amount of information. Dealing with such enormous amount of information can be regularly existing problems. In digital science must be gathered and replaced in a well-organized method, so that it to be placed to real-world usage. The wavelet compression is another technique to apply with this problematic [1].

The digital images cover the huge volumes of information a well-known conservation range, it consist of enormous transmission bandwidths along with lengthy transmission times. For that reason, it is useful to compress the image by accumulating only the vital information is essential to reorganize the given image. In wavelet performance analysis can be used to divide the block of information in an image into similarity and specific aspect of subsignals. The detail approximation of subsignal illustrates the wide-ranging leaning image of pixel values, and three detail subsignals demonstrates the vertical, horizontal and diagonal details or variations in the given image. If these details coefficients are identical lesser then it can be set to zero as well as significantly shifting the image pixel values [2].

The lossy compression, original signal inclined be fine restored from the compressed information. The objective is that, plenty of the elements in an image can be rejected beyond significantly altering the presence of an image. In the process of deliberate an image of a tree, which attains various hundred megabytes. In lossy image compression technique, after all exact acceptable information's of the images is consumed; however the image size is extremely decreased. In lossy image compressions are effective in an applications comparatively broadcast television, video conferencing, and facsimile transmission, wherever an actual quantity of error is an adequate establishment for better compression achievement. The approaches for lossy image compression contain: Fractal image compression, Transform image coding, Fourier-related transform, DCT (Discrete Cosine Transform) and Wavelet image transform [3].

In this research work aggregate of an image compression utilizing the Haar wavelet in DCT&DWT with Run Length Coding techniques that consequence less computational complexity with no loss in image aspect. The attainment of the proposed combined algorithm of DCT & DWT approach has been compared with some other common image compression standards like JPEG and GIF. Numerous quality measurement variables like peak signal to noise ratio (PSNR), mean square error (MSE) and compression ratio (CR) have been expected to describe how fine an image is simulate with respect to the tested grayscale image. In this article is organized as follows: Section II review of related research work based on run length coding schemes and different wavelet approach. Section III illustrates the steps involved in wavelet transform, Section IV presents the proposed method using DCT&DWT combined Run Length Coding, Section V demonstrates the experimental results and discussions. Finally, Section VI concludes the future directions.

II. REVIEW OF RELATED WORKS

The image compression can be able to perform well by the use of encoding approaches, spatial domain methods and

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transform domain techniques. The encoding techniques are clearly tested with the grayscale images. In general encoding techniques consist of entropy encoding methods that contain Huffman encoding algorithm and arithmetic encoding scheme, run length encoding and dictionary based encoding methods. The spatial domain techniques, which can complete entirely on the pixels of the image, it accumulate spatial domain algorithms including the encoding techniques. The transform based domain techniques are the image from belonging to its spatial domain description of a various type of illustration testing with well-known transforms [4].

In relatively running secure image compression algorithms for the state-of-the-art using the transform based along with them are the Discrete Cosine Transform (DCT) based techniques. This can be completely a lot of communications for the successful compression methods which includes the JPEG image standard [5]. In the earlier periods, the Discrete Cosine transform out-of-date the best standard method for image encoding, as a result of its excellent accomplishments and this technique can be perform well with implemented about; a feasible amount of information. This can be compared to DFT [6], the application of DCT performance results is smaller amount of blocking artifacts by reason of the even-symmetric development prospect of DCT. In Discrete Cosine Transform approach is needed to a real working analysis, dissimilar the complex calculations are used in the Discrete Fourier Transform. The Discrete Fourier Transform creates the form of DCT hardware is a easiest way to understand and it is related with Fourier Transform. The indicated methods, improvements need to develop a DCT based grayscale image compression of very common still-image and multimedia encoding regulations. The DCT is a approach for the implemented with exchanging a signal into its basic frequency components. Generally the image is disintegrated into numerous blocks of the image, and this can be applied for every block of the original image, the DCT is mathematical way of declared as a group of cosine functions vary at distinct frequencies. After all, the technique is fine-tune the given images, this can be completely the 2D description of Discrete Cosine Transform, that can be attained from the decline of two one dimensional Discrete Cosine Transform [7].

In transform based compression methods generally contains three steps: Transforming the information, quantizing the coefficients, and lossless compression of the reconstructed image. The compression applying Discrete Cosine Transform [8] is divided up to the original image into 8×8 pixel blocks and then computes the discrete cosine transform for every block size. Quantizer is culminating the DCT coefficients accede to the quantization matrix of the given image. This accomplishment produces the "lossy" description, although it concedes for higher compression ratios. This compression technique can be used as variable length code on applying these coefficients, and consequently it address the compressed information into a reconstructed data. For, decompression steps, it retrieve the quantized DCT coefficients from the compressed data stream, that proceeds the reverse transforms and displays the output image [9].

Though a collection of recent and effective techniques further have been modified for image compression beyond the years, the wavelet established image compression has attained a lot of acceptance being their extending process that decreases the blocking artifacts and multiresolution aspect that is noted to better energy character with eminent feature of restored images. In wavelet based encoding [10] that affords significant advances in the picture quality analysis at leading compression ratios. Moreover the analysis of efficient compression ratios in wavelet based encoding techniques can be reducing almost nearly than the block based Discrete Cosine Transform techniques. The Discrete Wavelet Transforms is performing to determine the blocking artifact has been presented through the DCT. Besides it decreases the correlation among the neighboring pixels and it provides multi scale sparse description of the image.

In lossy compression comprises the common JPEG (Joint Photographic Experts Group. The JPEG [11] is a technique to create the compressed images with 24 bits depth or grayscale images. This algorithm utilizes a transform encoding method, i.e. the DCT. One of the aspects that produce the algorithm very alterable is that the compression rate can be adapted. If a lot of compression is concluded for more instruction but the resultant grayscale image block size will be lesser with a minimum compression rate and good image quality will be attained, but the size of the reconstructed image will be bigger. This image compression develop into the creating the coefficients in the quantization matrix is larger though high compression is required and lower when minimum compression is desired. The compression technique is established on two descriptive things of the human visual system. Earlier, humans are higher sensitive to the brightness than to the chrominance. After that, humans are more perspective to modify in consistent areas, than in areas where there are high modification (superior frequencies) [12]. The JPEG is the highest used format for storing and transmitting the images in Internet.

The JPEG 2000 [11, 12] is a reformed version of the JPEG basics to gain the compression rates and arranged number of state-of-the-art features like, area of interest encoding and progressive encoding scheme. In JPEG2000 image compression basics are using the both image compression techniques. The scheme of JPEG 2000 was to contribute a better rate distortion arrangement and improved built-in image quality. JPEG-2000 is established on the wavelet encoding method and implements an expanded flexibility in both the lossless and lossy compression of continuous-tone still images and acquire to the compressed information [11, 12].

The DCT and DWT are the two essential transforms in image encoding. Whereas the block DCT and wavelet encoding be equal to the quality is different, therefore some correlation. The resembling wavelets arrange the both spatial and frequency domain information, this technique demonstrates that DCT also implements related data [18]. The main characteristics between the DCT and DWT coefficients distortion in the high pass bands. The high pass DCT band gives the higher frequency decision, but in minimum spatial resolution. The result of DCT & DWT, there is more frequency bands, but it is challenging to observe the spatial information. The alternative ways of the wavelet sub bands produce a greater spatial resolution, and

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minimum frequency investigation. As a performance of the technique, the number of sub bands is less, although the spatial resolution is exceptional.

The Run Length Encoding is a very clear method of image compression to which sequence runs of information are stored as a single data value and count the repeated information, in preference as the original run. It is exhausted for sequential [14, 15, and 16] information and it is essential for consecutive data. This RLE technique process over the arrangement of exact pixels named as runs.

In this research work, grayscale information and two dimensional grayscale data are studied with the resource of a Run Length Coding method & DCT, DWT approach. The proposed Run Length Coding in Wavelet compression is applied to every pixel of the image, some pixels can be agreeable compressed while some pixels are the worst-case. So, it is indispensable to develop a modern and efficient approach to design the proposed method of Run Length Coding in wavelet compression is to implement grayscale images.

III. Steps Involved in Wavelet Compression

The following steps are essential to compress an image

- To compute the source image into a signal s, that is a set of string and numbers.
  - The first step in the wavelet compression process is to digitize the given test image. The digitized image can be described by its intensity levels, or scales of gray value which range from 0 (black) to 255 (white), and its decision.
- Then, decompress the signal into a sequence of repeated information in wavelet coefficients w.
  - In valid image pixel value, frequent of the wavelet coefficients are very close or equal to zero. This completed method is called thresholding of various levels, these coefficients may be altered thereby, and the sequence of wavelet coefficients consists of enormous amount of strings in zeros.
- The wavelet coefficient use thresholding to modify the value w to another sequence w'.
  - In consideration of development given image, symmetric biorthogonal wavelets are used. These have two father and two mother wavelets, and are required in order to compress a matrix of given information.
- After applying the wavelet coefficients, apply the quantization to convert w' to a sequence q.
  - It altered a sequence of floating numbers w' to a sequence of integers q. The easiest form is to round to the nearest integer value. Something else, is to multiply each number in w' by a constant k, and then round to the nearest integer value.
- Finally, apply the entropy encoding technique to Compress the given information, i.e. q into a sequence.
  - The entropy encoding is developed for applying compress the given data, in order that, the numbers that are normal to appear about to often in q, it is used the least amount of space in entropy.

IV. Proposed Method

A. Run Length Coding in Wavelet Compression

The proposed method persuades an input image and divides it into a number of 8×8 non-overlapping sub-blocks. For the first blocks, Wavelet Run length Coding algorithm combines the DCT and DWT approaches to reduce the non-zero values then reorganizes the sequential number from the sub-block matrix with apply the enhanced run length coding, After apply the techniques the reconstructed image can be reduced effectively.

B. Algorithm

1) Encoding Algorithm

a) Get a grayscale image with different format.
b) Arrange reshape size with 512 × 512 Images.
c) An image is divided into 8 ×8 non overlapping block size.
d) Transformation is applied in three steps
   1) Group all the column pairs.
   2) Replace the first 4 column in average pairs and last 4 columns $\frac{1}{2}$ of the difference of the pairs.
   3) Then group the first four column of new row. Replace first two columns of r1h1 with the average pairs and next two columns of the $\frac{1}{2}$ difference of the pairs.
e) Apply Quantization for rounding the integer values.
f) Then apply the run length coding with 3 level Haar wavelet transformations WRLC.
g) Repeat this process until last block.
h) Generate Compression ratio, PSNR, MSE for all blocks.

2) Decoding Algorithm

a) Read the compressed image.
b) Convert the compressed image into matrix format.
c) Inverse process of quantizer into number of non-overlapping blocks.
d) Inverse process of DCT&DWT transformation.
e) Apply Inverse of Inverse process of WRLC.
f) Get the reconstructed image.
g) Repeat Step b to Step f to process the whole block size.
h) Concatenate the reconstructed image.

C. Block Diagram

The completed proposed Wavelet based Run Length Coding (WRLC) diagram for encoding and decoding is presented in figure 1. In compression encoder is generated for each block applied with the combination of

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DCT&DWT approach with Run Length Encoding scheme with 3 level wavelet transformations to get the enhanced method of producing the good compression rate. Similarly decoder is generated for the inverse of compression to get the original data.

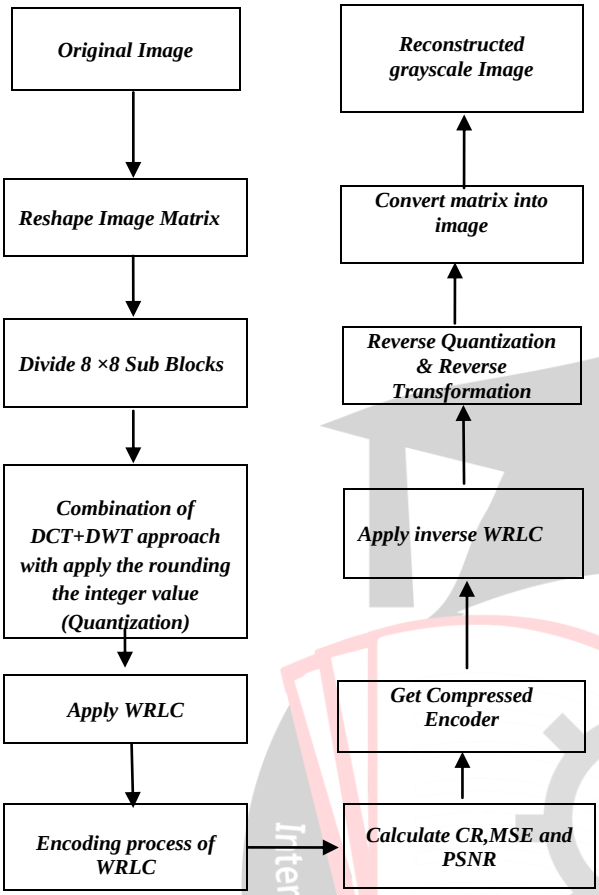

Figure 1. Proposed WRLC Block Diagram.

V. Results and Discussion

A. Experimental Results

In this section, the proposed WRLC method has been applied on three different grayscale images. The original Lena test image is presented in figure 2 (a). The reconstructed image is employed in figure 2 (b) with the block size 512×512.

The proposed method WRLC is tested with another image of cameraman image. The original cameraman image is revealed in figure 3 (a). The reconstructed image displays in figure 3(b). The original Mandril image is presented in 4(a) and the reconstructed image shown in figure 4(b).

Figure 2(a). Original Lena Image

Figure 2(b). Reconstructed image 512×512.

Figure 3(a). Original Cameraman Image.

Figure 3(b). Reconstructed image 512×512.

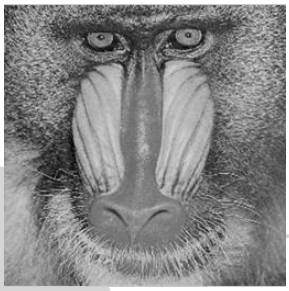

Figure 4 (a).Original Mandril Image

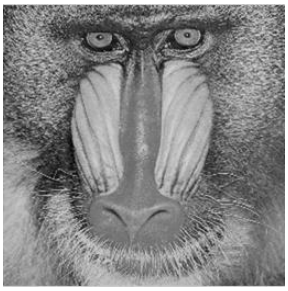

Figure 4(b). Reconstructed image 512×512

Moreover the block size 512×512 gives significant compression ratio when we apply the DCT & DWT compression techniques with greater pixel redundancy for efficient compression rate 1.29 KB in Lena grayscale image for the threshold level 20 and the threshold level 15 gives 1.63 KB, the compression rate is reduced for decreasing the threshold value. The threshold value 10 produces 2.57 KB, threshold value 5 accepting 4.53 KB. The images were obtained from USC-SIPI image database [17].

This paper displays the standard test images like Lena, Cameraman and Mandril images that give the high compression ratio with blocking artifacts can be reduced in WRLC in lossy compression. The WRLC different grayscale images in 512×512 block size. The proposed WRLC technique attains an improved compression rate with good quality of reconstructed image.

B. Performance Analysis of Quality Measurement

An image quality of greater importance is given to sharpness rather than tone reproduction. Subjective image quality measurements are done either directly or indirectly. In order to ascertain the image quality, the proposed work has been implemented for different size of block and evaluated Compression Ratio (CR), Computation Time (CT) and Mean Square Error (MSE).

From the Table I tested and analyzed with the Lena image size is 264588, it is observed that the compressed file size is the $\sigma = 20$ produce the good compression rate of 1.29 KB for enormous amount of information can be reduced in the tested image of Lena for the block size is applied with 512×512.

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TABLE I. QUALITY MEASUREMENT FOR LENA IMAGE SIZE OF 264588

Block Size	Quality Measurement for Lena Image					
	Thres hold values	*MSE*	*PSNR*	*Compressed Size*	*Size of Compressed image with WRLC*	*CT*
512×512	$\sigma = 5$	467	16.61	58392	4.53 KB	7.59
512×512	$\sigma = 10$	118	20.05	102601	2.57 KB	10.92
512×512	$\sigma = 20$	68	24.96	204561	1.29 KB	12.20

In Table II, the results are based Cameraman test image data. Measurement of this table states the quality of the image which calculates Peak Signal to Noise Ratio, Mean Square Error, Compression Ratio and Computation Time (CT). It achieves the threshold level 20 compression rate is 1.33 KB and the MSE can be measured 49.

TABLE II. QUALITY MEASUREMENT FOR CAMERAMAN IMAGE SIZE OF 252624.

Block Size	Quality Measurement for Cameraman Image					
	Thres hold values	*MSE*	*PSNR*	*Compressed Size*	*Size of Compressed image with WRLC*	*CT*
512×512	$\sigma = 5$	157	8.79	40452	6.24 KB	7.77
512×512	$\sigma = 10$	113	21.96	86120	2.93 KB	9.24
512×512	$\sigma = 20$	49	26.38	198602	1.27 KB	11.02

The Table III shows the results of MSE, PSNR, CR and CT are Mandril test image for the block size of 512×512. It is observed that the proposed method achieves the compressed file size is 181564 and the same time compression ratio is gradually increasing while the threshold level increases.

TABLE III. QUALITY MEASUREMENT FOR MANDRIL IMAGE SIZE OF 264534.

Block Size	Quality Measurement for Mandril Image					
	Thres hold values	*MSE*	*PSNR*	*Compressed Size*	*Size of Compressed image with WRLC*	*CT*
512×512	$\sigma = 5$	754	14.53	38457	6.87 KB	4.58
512×512	$\sigma = 10$	323	18.45	98457	2.68 KB	9.45
512×512	$\sigma = 20$	74	27.38	181564	1.45 KB	13.01

C. Comparative Analysis

The table IV shows the comparison between different formats of JPEG, GIF and the proposed compression method. The experimental results demonstrate that the proposed compression technique gives better performance compared to other compression techniques. The figure 5 shows the graphical representation of CR in WRLC with other existing methods.

TABLE IV. COMPARATIVE ANALYSIS CR WITH OTHER EXISTING METHODS.

Image	Comparative analysis for compression ratio with other existing methods		
	JPEG	*GIF*	*WRLC*
Lena	6.8 KB	12.04 KB	1.29 KB
Cameraman	5.9 KB	11.02 KB	1.27 KB
Mandril	6.7 KB	12.02 KB	1.45 KB

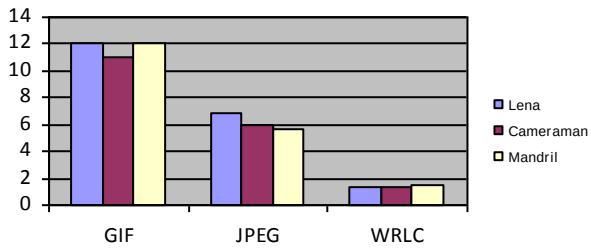

Figure 5. Comparative Analysis CR with Existing Methods

The table V displays the comparison with existing methods like JPEG, WBIC-DCT and WBIC-DWT approach. The experimental analysis presented with computation time shows the reduced time rate than other existing methods.

TABLE V. COMPARATIVE ANALYSIS COMPUTATION TIME WITH OTHER EXISTING METHODS.

Image	Comparative analysis for Computation Time with other existing methods			
	JPEG [19]	*WBIC-DCT[19]*	*WBIC-DWT [19]*	*WRLC*
Lena	15.04	14.22	15.01	12.20
Cameraman	14.12	13.81	11.01	10.02
Mandril	15.98	15.02	14.27	13.01

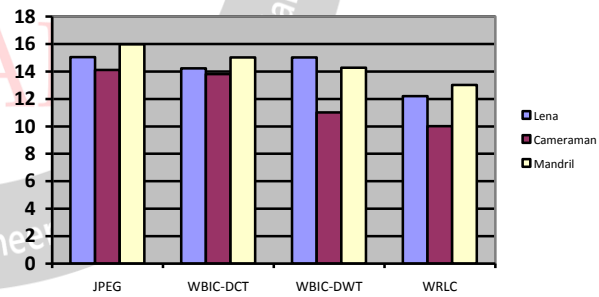

Figure 6. Comparative Analysis CT with Existing Methods.

The figure 6 displays the graphical representation of CT in WRLC with other existing methods. The WRLC produce the efficient and fastest time to compute the grayscale images than other existing methods.

VI. CONCLUSION AND FUTURE DIRECTIONS

The proposed WRLC compression technique produce improved performance related to the other traditional techniques. The wavelet based compression technique maintains better image quality by reducing errors for combined DCT+DWT approach used with the run length coding.

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The Proposed WRLC algorithm provides the compress well the standard test image of Lena is 22.29 spaces saving for compressed images. The WRLC algorithm also compares the computation time is compared with the state-of-art JPEG compression techniques. The research finding of WRLC is reduce the enormous amount of information and effectively computes the computation time is 12.20 whereas, JPEG computes the time is 15.04 secs to compress the grayscale images.

The future direction of this research work is to implement a compression technique using neural network, audio, video image compression, genetic algorithm and deep learning approach.

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