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Hybrid Algorithm for Efficient Image and Video Compression

T. Venkata Ramana[1], Dr. S. A. K. Jilani[2]
[1]Research Scholar, Department of ECE, Rayalaseema University, Kurnool, AP, India
[2]Professor, Department of ECE, MITS College, Madanapalle, A.P, India
[1]tvramana812@gmail.com, [2]jilani_consult@yahoo.com

Abstract: ***With the limitation of bandwidth and data rate for transfer, the need of the hour is the compressed data. Especially for images and videos, the data consumed is very high and requires very large storage buffers. Thus the compression of data is one of the choices to restrict size of data that is transmitted at a time. The image compression can be done either without loss in data and with some acceptable loss in data. As redundant data can be avoided and some loss in data is acceptable for images and videos, Lossy Image Compression Techniques have evolved. Among them, transformations can be applied on the original image to compress the data contained in it. In this paper the comparison is made against various transforms like discrete wavelet transform, discrete cosine transform and hybrid algorithms. The parameters considered for comparison are the image Ratio of compression, peak signal to noise ratio, and mean square error. The algorithms will developing in MATLAB and are verified for different images. As the video is a converted form of a sequence of images merged as frames, the same algorithm can be applied to video compression also. The Hybrid DCT-DWT algorithm proved to be a better choice for image and video compression.***

Keywords: Compression Ratio (CR), Hybrid Algorithm, Peak Signal to Noise Ratio (PSNR), Mean Square Error (MSE).

I. INTRODUCTION

The modern era has the evolved technologies that transfer bulk data like images and videos [11][13]. Hence due to limitations in data rate of transfer and bandwidth, new techniques related to compression of images and videos have evolved [15]. Among them Lossy compression is proved to be a good choice as it avoids the large buffer sizes required for data storage and minimum length of data for transfer[5][6][7]. As the raw data transmission consumes larger bandwidth and it requires huge storage space; so, it is wanted to represent the information in the data by means of considerably fewer bits using data compression techniques [1][2][12]. At the same time, compression method must be able to rebuild the data very near to original data. This can be achieved through an effective and efficient compression and decompression algorithms [8][9][10]. The DWT and DCT are the mainly used algorithms [3][4][14]. The figure 1 shows the flow chart of the image compression process as performed in this paper. This paper is organized as section II describes the DCT and DWT Transforms with their corresponding drawbacks. To overcome these, hybrid algorithms are introduced in section III, the advantages of DWT and DCT are added. Section IV describes the corresponding simulation results and comparison. Section V concludes the paper followed by references.

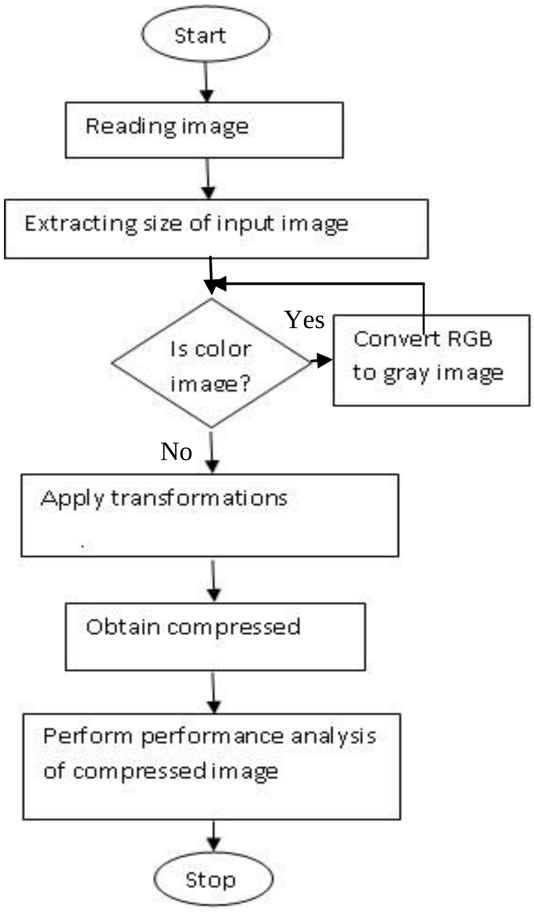

Fig. 1. Flow Chart of Image Compression Process

II. DCT AND DWT TRANSFORMS

The DCT has property of high energy compaction and requires less number of computational resources. The energy compaction property of an algorithm refers to the ability to concentrate most important information signal into as much as few low frequency component. The DWT is a multi-resolution transform and variable compression can be easily achieved. The DCT can be applied as a forward DCT or backward DCT. The expression for corresponding forward DCT is given by

$$X(m) = u(m)\sqrt{\frac{2}{N}}\sum_{i=0}^{N-1} x(i)\cos\frac{(2i+1)m\pi}{2N}, \text{ for } m = 0, 1, \ldots, N-1,$$

$$\text{where } u(m) = \begin{cases} 1 & \text{for } m = 0; \\ \frac{1}{\sqrt{2}} & \text{otherwise.} \end{cases}$$

and the expression for Backward DCT is given by

$$x(i) = \sqrt{\frac{2}{N}} \sum_{m=0}^{N-1} u(m) X(m) \cos \frac{(2i+1)m\pi}{2N}$$

The DCT technique algorithm is given by

- First the Matrix initialization is done for the input image.
- The quantized and normalized DCT compression is performed on the image
- Zigzag coding of each 8x8 block is performed and unused variables are cleared from memory space.
- Run length encoding of the resulting image is performed
- Run length decoding of the compressed image is performed
- Zigzag decoding of the 8x8 blocks is performed
- Denormalizing the Reconstructed Tranform matrix is performed.
- Inverse-Discrete Cosine Transform on the reconstructed Matrix is performed to obtain the compressed and DCT processed image.

The basic idea of the WT is to represent the signal to be analysed as a superposition of wavelets. The wavelet can be described by using two functions, the scaling function φ(t), known as 'father wavelet'. The wavelet function ψ(t) or 'mother wavelet'. Combining this obtains a daughter wavelet. A family of wavelets can be generated by dilation and translating the mother wavelet ψ(*x*). Figure 2 represents one step in a multi scale pyramid decomposition of an image. The algorithm applies a one dimensional high and low pass filtering step to the rows and columns separately in the input image. The inverse transform filter bank structure is represented in Figure 3. The main disadvantages of DCT are introduction of false contouring effects and blocking artifacts at higher compression, and, that of DWT is requirement of large computational resources. So, the idea of exploring the advantages of both algorithms motivated us to investigate combination of DWT and DCT algorithms. Such combination of two algorithms is referred as 'hybrid' algorithm.

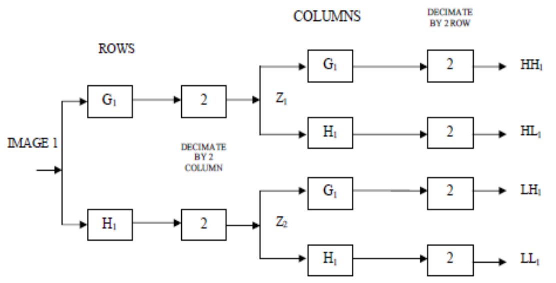

Fig. 2. Filter Bank Structure of the DWT. Analysis

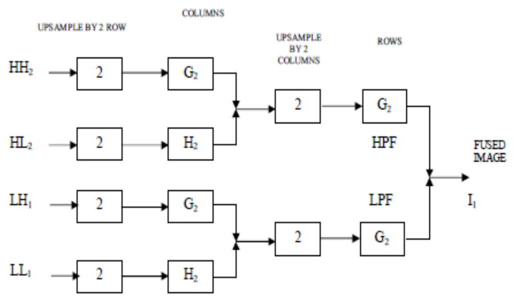

Fig. 3. Filter Bank Structure of the Reverse DWT Synthesis

III. HYBRID DCT-DWT AND DWT-DCT ALGORITHMS

The Hybrid algorithms aim at integrating the advantages of both DWT and DCT Algorithms. Two combinations are devised to use for image compression techniques. The combinations are Hybrid DCT-DWT and Hybrid DWT-DCT Algorithms. These algorithms are explained below.

The Hybrid DWT-DCT Algorithm is given as below:

- The input image is read and its size is extracted.
- If a color image is read, it is converted into a gray image.
- Apply DWT algorithm to get a set of 4 decomposed frequency band coefficients for each images.
- For each respective image's decomposed frequency band coefficients, apply FDCT wrapping transformation to get respective curvelet descriptor coefficients of all set of decomposed coefficients.
- To regenerate, sets of frequency bands from above stage's resultants are applied with inverse FDCT wrapping to respective coefficients.
- After getting a set of four frequency coefficients, apply inverse DWT to reconstruct the final image.
- Using input image as reference image and final image, evaluate the performance of the algorithm.

The Hybrid DCT-DWT Algorithm is given as below:

- The input image is read and its size is extracted.
- If a color image is read, it is converted into a gray image.
- Apply DCT algorithm to get a compressed image to get respective curvelet descriptor coefficients of all set of decomposed coefficient.
- Now apply DWT algorithm to get a set of 4 decomposed frequency band coefficients for each images.
- After getting a set of four frequency coefficients, apply inverse DWT to reconstruct the final image.
- For each respective image's decomposed frequency band coefficients, apply FDCT wrapping transformation s.

- To regenerate, sets of frequency bands from above stage's resultants are applied with inverse DCT wrapping to respective coefficients.
- Using input image as reference image and final image, evaluate the performance of the algorithm.

The steps are slightly varied at the step of applying the transformation techniques in the flow chart shown in figure 1. The corresponding DCT, DWT, Hybrid DWT-DCT and Hybrid DCT-DWT algorithms are replaced in the transform techniques applied in the flow chart.

IV. SIMULATION RESULTS

A. Cameraman Image:

The algorithms are developed in MATLAB and are analyzed for cameraman image as shown in fig. 4.

Fig. 4. Original Image

The compressed images are shown in figure 5 for DCT algorithm, figure 6 for DWT algorithm.

Fig. 5. DCT Compressed Image

Fig. 6. DWT Compressed Image

The compressed images are shown in figure 7 for Hybrid DCT-DWT algorithm, figure 8 for Hybrid DWT-DCT algorithm.

Fig. 7. Hybrid DCT-DWT Compressed Image

Fig. 8. Hybrid DWT-DCT Compressed Image

Table 1 gives the comparison between the four algorithms, i.e., DCT, DWT, Hybrid DWT-DCT and Hybrid DWT-DCT Algorithms. The parameters used for comparison are CR (Compression Ratio), MSE (Mean Square Error) and PSNR (Peak Signal to Noise Ratio).

The Compression Ratio is the ratio of uncompressed data volume (S_{uncomp}) to the compressed data volume (S_{comp}). Hence CR = S_{uncomp} / S_{comp}

The MSE(mean square error) gives the noise approximation of the compressed image by using the equation 1 as

$$MSE = \frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I(i,j) - K(i,j)]^2 1$$

The PSNR (peak signal to noise ratio) in dB is a measure of the quality of the reconstruction of compressed images by using the equation 2 as

PSNR=10 Log $_{10}$ (MAX_I^2 / MSE)

=20 Log $_{10}$ (MAX_I/SQRT(MSE))

= 2O Log $_{10}$ (MAXI)-10 Log $_{10}$ (MSE)

From Table I, it is clear that the DWT algorithm has highest compression ratio, the PSNR is maximum for hybrid DCT-DWT algorithm and the MSE is less for Hybrid DCT-DWT Algorithm.

Table 1. Comparison between three PFDs 2

Compression Method	Compression Ratio	Mean Square Error	Peak Signal to Noise Ratio
DCT Algorithm	13.3745	124.9791	27.1624
DWT Algorithm	20.5696	21.4224	34.8221
Hybrid DWT-DCT Algorithm	13.0239	124.8890	27.2193
Hybrid DCT-DWT Algorithm	12.7055	12.3354	37.2193

B. Barbara Image:

The algorithms are developed in MATLAB and are analyzed for *Barbara* image as shown in figure 9.

Fig. 9. Original Image

The compressed images are shown in figure 10 for DCT algorithm, figure 11 for DWT algorithm.

Fig. 10. DCT Compressed Image

Fig. 11. DWT Compressed Image

The compressed images are shown in figure 12 for Hybrid DCT-DWT algorithm, figure 13 for Hybrid DWT-DCT algorithm.

Fig. 12. Hybrid DCT-DWT Compressed Image

Fig. 13. Hybrid DWT-DCT Compressed Image

Table 2 gives the comparison between the four algorithms, i.e., DCT, DWT, Hybrid DWT-DCT and Hybrid DWT-DCT Algorithms. The parameters used for Comparison are CR (Compression Ratio), MSE (Mean Square Error) and PSNR (Peak Signal to Noise Ratio0.

The Compression Ratio is defined as the ratio of uncompressed data volume (S_{uncomp}) to the compressed data volume (S_{comp}). Hence CR = S_{uncomp} / S_{comp}

The MSE (mean square error) gives the noise approximation of the compressed image by using the equation 3 as

$$MSE = \frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I(i,j) - K(i,j)]^2 \quad 3$$

The PSNR (peak signal to noise ratio) is a measure of quality of reconstruction of compressed images by using the equation 4 as

$PSNR=10 \log_{10} (MAX_I^2 / MSE)$

$=20 \log_{10} (MAX_I/SQRT(MSE))$

$= 2O \log_{10} (MAXI)-10 \log_{10} (MSE)$ 4

Table 2. Comparison between three PFDs

Compression Method	Compression Ratio	Mean Square Error	Peak Signal to Noise ratio
DCT Algorithm	9.6043	123.6923	27.2074
DWT Algorithm	7.8280	21.2412	34.8590
Hybrid DWT-DCT Algorithm	9.5739	126.1526	27.1218
Hybrid DCT-DWT Algorithm	9.2948	19.5409	35.2214

From Table II, it is clear that the DWT algorithm has highest compression ratio, the PSNR is maximum for hybrid DCT-DWT algorithm and the MSE is less for Hybrid DCT-DWT Algorithm.

C. Lena Image:

The algorithms are developed in MATLAB and are analyzed for Lena image as shown in figure 14.

Fig. 14. Original Image

The compressed images are shown in figure 15 for DCT algorithm, figure 16 for DWT algorithm.

Fig. 15. DCT Compressed Image

Fig. 16. DWT Compressed Image

The compressed images are shown in figure 17 for Hybrid DCT-DWT algorithm, figure 18 for Hybrid DWT-DCT algorithm.

Fig. 17. Hybrid DCT-DWT Compressed Image

Fig. 18. Hybrid DWT-DCT Compressed Image

Table 4 gives the comparison between the four algorithms, i.e., DCT, DWT, Hybrid DWT-DCT and

Hybrid DWT-DCT Algorithms. The parameters used for comparison are CR (Compression Ratio), MSE (Mean Square Error) and PSNR (Peak Signal to Noise Ratio).

The Compression Ratio is defined as the ratio of uncompressed data volume (S_{uncomp}) to the compressed data volume (S_{comp}). Hence CR = S_{uncomp} / $S_{comp.}$ The MSE (mean square error) gives the noise approximation of the compressed image by using the equation5 as

$$MSE = \frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I(i,j) - K(i,j)]^2 5$$

The peak signal to noise ratio in dB is a measure of the quality of reconstruction of lossy compressed images by using the equation6 as

$$PSNR=10 \text{ Log}_{10} (MAX_I^2 / MSE)$$
$$=20 \text{ Log}_{10} (MAX_I/SQRT(MSE))$$
$$= 2O \text{ Log}_{10} (MAXI)-10 \text{ Log}_{10} (MSE) \quad 6$$

Table 3. Comparison between Three PFDs

Compression Method	**Compression Ratio**	**Mean Square Error**	**Peak Signal to Noise ratio**
DCT Algorithm	11.2504	92.7095	28.4596
DWT Algorithm	8.8496	21.3495	34.8369
Hybrid DWT-DCT Algorithm	11.2365	95.4647	28.3324
Hybrid DCT-DWT Algorithm	10.8151	18.4416	35.4728

From Table 3, it is clear that the DWT algorithm has highest compression ratio, the PSNR is maximum for hybrid DCT-DWT algorithm and the MSE is less for Hybrid DCT-DWT Algorithm.

D. Rice Image:

The algorithms are developed in MATLAB and are analyzed for rice image as shown in figure 19.

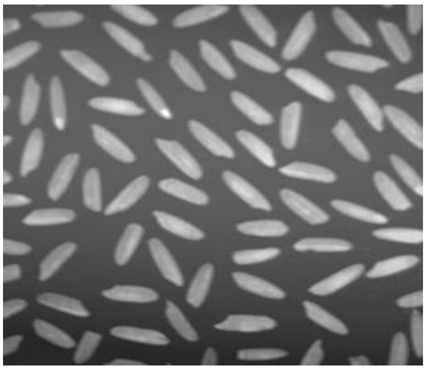

Fig. 19. Original Image

The compressed images are shown in figure 20 for DCT algorithm, figure 21 for DWT algorithm.

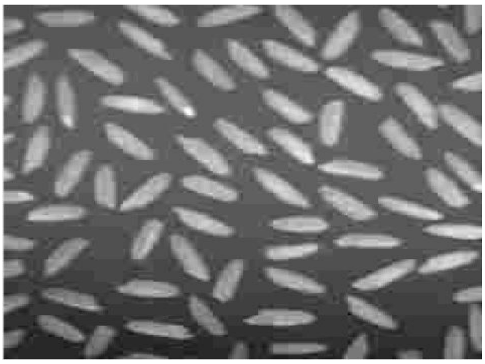

Fig. 20. DCT Compressed Image

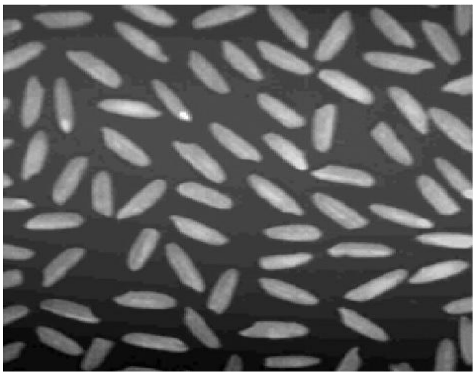

Fig. 21. DWT Compressed Image

The compressed images are shown in figure 22 for Hybrid DCT-DWT algorithm, figure 23 for Hybrid DWT-DCT algorithm.

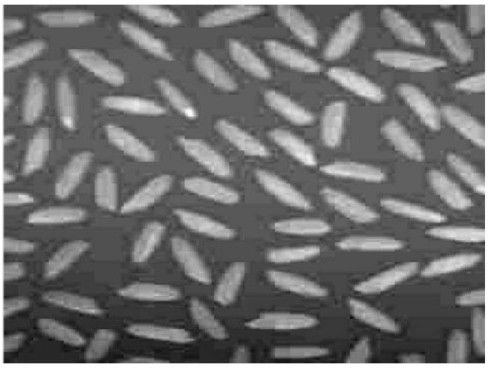

Fig. 22. Hybrid DCT-DWT Compressed Image

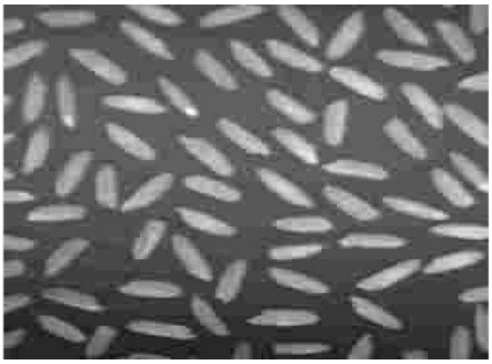

Fig. 23. Hybrid DWT-DCT Compressed Image

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Table 4 gives the comparison between the four algorithms, i.e., DCT, DWT, Hybrid DWT-DCT and Hybrid DWT-DCT Algorithms. The parameters used for comparison are CR (Compression Ratio), MSE (Mean Square Error) and PSNR (Peak Signal to Noise Ratio).

The Compression Ratio is defined as the ratio of uncompressed data volume (S_{uncomp}) to the compressed data volume (S_{comp}). Hence CR = S_{uncomp} / S_{comp}

The MSE (Mean Square Error) gives the noise approximation of the compressed image by using the equation7 as

$$MSE = \frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I(i,j) - K(i,j)]^2 7$$

The PSNR (peak signal to noise ratio) in dB is a measure of the quality of reconstruction of compressed images by using the equation 8 as

PSNR=10 Log $_{10}$ (MAX_I^2 / MSE)

=20 Log $_{10}$ (MAX_I/SQRT(MSE))

= 2O Log $_{10}$ (MAXI)-10 Log $_{10}$ (MSE) 8

Table 4: Comparison between Three PFDs

Compression Method	**Compression Ratio**	**Mean Square Error**	**Peak Signal to Noise ratio**
DCT Algorithm	11.5823	42.3159	31.8658
DWT Algorithm	20.5696	20.3185	35.0519
Hybrid DWT-DCT Algorithm	11.6819	43.8865	31.7075
Hybrid DCT-DWT Algorithm	10.8688	17.2536	35.7620

From Table V, it is clear that the DWT algorithm has highest compression ratio, the PSNR is maximum for hybrid DCT-DWT algorithm and the MSE is less for Hybrid DCT-DWT Algorithm.

V. CONCLUSION

The lossy compression algorithms are used to overcome the large bandwidth and huge storage space requirements where the information in the data with considerably fewer bits. Also the data can be reconstructed very close to original data. The efficient & effective compression and decompression methods are used for lossy compression. The algorithms chosen for implementation are DCT and DWT algorithms. But due to limitations like DCT introduces false contouring effects and blocks artifacts at higher compression, and DWT requires large computational resources. The concept of hybridization evolved which enhances the advantages of both DWT and DCT algorithms and reduces the limitations of both algorithms. Two hybrid algorithms were devised for compression of images. The algorithms are simulated and the parameters are evaluated in Matlab. Among the hybrid algorithms, Hybrid DWT-DCT algorithm has minimum MSE (Mean square error) and better CR (compression ratio). But the Hybrid DCT-DWT algorithm has good PSNR.

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