Adaptive Video Compression using Discrete Cosine and Wavelet Transform

M. Mary Shanthi Rani[1]
Assistant Professor, Department of Computer Science & Applications
The Gandhigram Rural Institute-Deemed University
Gandhigram-624 302 Tamil Nadu, India.
drmaryshanthi@gmail.com

P. Chitra[2]
Ph.D. Scholar, Department of Computer Science & Applications
The Gandhigram Rural Institute-Deemed University
Gandhigram-624 302 Tamil Nadu, India.
bchitra.tr@gmail.com

K. Anandharaj[3]
M.Phil Scholar, Department of Computer Science & Applications
The Gandhigram Rural Institute-Deemed University
Gandhigram-624 302 Tamil Nadu, India.
anand.student@yahoo.com

Abstract— ***Video compression is a process of eliminating redundancy and irrelevant information for efficient storage and transmission. Discrete Cosine Transform (DCT) and Discrete Wavelet Transform (DWT) are the popular transforms used for efficient compression. DCT has high energy compaction and requires less computational resources. In this paper, a novel method is proposed combining DCT, DWT and Arithmetic coding for compressing the video. Arithmetic coding is used to optimize data, generating minimum redundancy code. Experimental results demonstrate the superior performance of the proposed method than similar terms of achieving high PSNR value and compression ratio.***

Keywords- DCT, DWT, Motion Estimation, Motion Compensation, Quantization, Arithmetic coding.

I. INTRODUCTION

Videos play a crucial role in multimedia applications. Normally, video file occupies huge amount of memory to store. A video file of 40 minutes of 30 frames per second frame rate and resolution of 750*570 will require 1.39 GB. The storage and bandwidth requirement of this uncompressed video is very high. Videos and images contain a large amount of redundant information. A video compression is reducing the size. While compressing the video there is tradeoff between the video quality and the amount of compression achieved. If the compression achieved is high the quality of the reconstructed video.

The DCT and DWT commonly used algorithms for video compression. The DCT has high energy compaction property and requires less computational resources. The energy compaction property of a method refers to the capacity to concentrate most essential information signal into as much as few low frequency component. The main advantage of applying DCT is to achieve high compression while maintain renovate the quality. The main objective of this research work is to investigate the performance of planned DCT –DWT and Arithmetic coding algorithm for wide range of image and video applications at various compression levels.

A. *Discrete Cosine Transform (DCT)*

The Process of DCT is similar to the Karhunen-Loeve Transform (KLT) and it requires less computational complexity. In addition, DCT has of higher energy compaction when compared to DFT, DST, WHT and DWT. Therefore, DCT is commonly used for image and video compression. However, for the higher compression, it introduces blocking artifacts and the outline effects in reconstructed image. As well as, it is not the multi-resolution transformation technique.

Limitations of DCT: High compression ratio, DCT has following two limitations.

- Blocking artifacts: Blocking artifacts is a distortion that appears due to higher compression and appears as abnormally large pixel blocks. For the higher compression ratio, the visible “blocking artifacts” across the block boundaries cannot be ignored.
- False contouring: The false contouring occurs when efficiently graded area of an image is distorted by an aberration that looks like a contour map for particular images having gradually shaded areas. The main cause of the fake contouring effect is the better quantization of the transform coefficients.

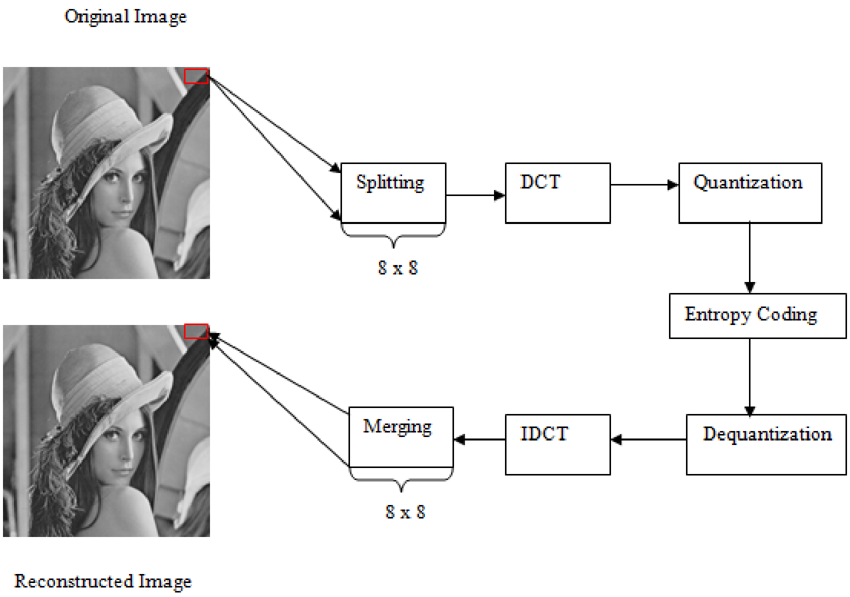


Fig 1: Block Diagram of DCT Process

B. *Discrete Wavelet Transform(DWT)*

The Discrete Wavelet Transform passing a signal to image, through a pair of filters, a low pass filter and a high pass filter. The low pass filter yields low resolution signal. The high pass filter yields difference signal. The outputs of these filters are down sampled by two. The down sampled outputs have the same number of bits as the input signal. The original signal is reproduced, when the up sampled output of the low pass filter is added to the up sampled output of the high pass filter. The output of the high pass filter is fed into another pair of filters and the process repeated. Haar wavelet transform is the simple example of discrete wavelet transforms [7].

The wavelet transform has gained widespread acceptance in signal processing and image compression. Because of their inherent multi-resolution nature, wavelet-coding schemes are especially suitable for applications where scalability and tolerable degradation are important. Recently the JPEG committee has released its new image coding standard, JPEG-2000, which has been based upon DWT. Discrete wavelet transform (DWT), which transforms a discrete time signal to a discrete wavelet representation.

C. *Quantization*

The quantization process follows transformation. The most suitable quantization process depends on the choice of transform used. A quantize is a non-linear device that chooses representative values for ranges of input data coming from the transform, either one at a time, which is called scalar quantization, or several at a time, called vector quantization.

Quantization is the fundamental step in achieving lossy compression. It reduces the magnitude of coefficients or rounds them to the nearest integer so that fewer bits are required to represent the image. Image frequencies are important here, because low frequencies correspond to important image features, whereas high frequencies correspond to details of the image which are less important. Thus, when a transform isolates the various image frequencies, pixels that correspond to high frequencies can be quantized heavily, whereas pixels that correspond to low frequencies should be quantized lightly or not at all. This is how a transform can compress a frames very effectively by losing information, but only information associated with less important image details.

D. Motion Compensation

Video can understand as a sequence of frames. Because two successive frames of a video sequence often have small differences (except in scene changes), the MPEG-standard offers a way of reducing this temporal redundancy. It uses three types of frames: I-frames (intra), P-frames (predicted) and B-frames (bidirectional).

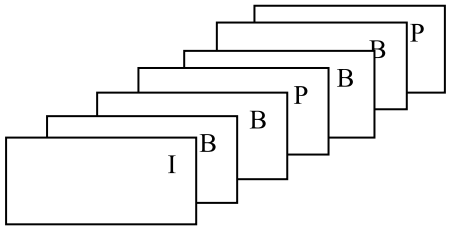


Fig 2: The Order of Frame Sequence

The I-frames are called as a "key-frames", which have no reference to other frames and their compression is not that high. The P-frames can be predicted from an earlier I-frame or P-frame. P-frames cannot be reconstructed without their referencing frame, but they need less space than the I-frames, because only the differences are stored [8]. The B-frames are a two-directional version of the P-frame, referring to both directions (one forward frame and one backward frame). B-frames cannot be referenced by other P- or B-frames, because they are interpolated from forward and backward frames. P-frames and B-frames are called inter coded frames, whereas I-frames are known as intra coded frame.

E. Arithmetic coding

Arithmetic coding is change the method of replacing each bit with a codeword. So, it replaces a string of input data with a single floating-point number as output. The main purpose of this technique is to given an interval to each potential bit data [12]. Arithmetic coding is a more modern coding method that usually than Huffman coding. Arithmetic coding can treat the whole string data as one unit. A message is represented by a half-open interval [a, b) where a and b are real numbers between 0 and 1. Initially, the interval is [0, 1). When the message becomes longer, the length of the interval shorts and the number of bits needed to represent the interval increases.

II. RELATED WORKS

Several existing methods have been proposed using DCT and DWT Techniques for video compression.

Dhaval R. Bhojani *et al.* (2012) [1] proposed an innovative video compression technique using DWT-DCT. This introduces the advancement in the video compression technology to improve the compression ratio, without losing much quality of the video.

T. Bernatin *et al.* (2014) [2] proposed a method on video coding scheme based on hybrid DWT- DCT transform, quantization and construction of minimum redundancy code using the Huffman coding is introduced. The proposed motion vectors found from estimation using adaptive rood pattern search and is compensated globally. The hybrid DWT- DCT transform exploits the properties of both the DWT and DCT techniques and provides a better compression. The hybrid compressed frame is quantized and entropy coded with Huffman coding for generated bit streams are transmitted to the decoder.

S. S. Wadd, *et al.* (2014) [4] discussed about Discrete Cosine Transform (DCT) based algorithm for compressing video. The advancement in video compression technology with visual quality and content of video. Block matching algorithms are used for motion estimation in video compression.

S.B. Midhun Kumar, *et al.* (2014) [6] presented a saliency-preserving framework for region-of-interest (ROI) video coding, whose main goal was to reduce attention-grabbing coding artifacts in non-ROI parts of the frame in order to keep viewer's attention on ROI parts where the video quality was higher. It is used to find a quantization parameter (QP) matrix for each and every video frame. So that the difference between the saliency map of the coded frame and the saliency map of original raw frame was minimized under a given target bit rate.

S.V. Phakad, *et al.* (2016)[7] described about a video compression using Hybrid (DCT-DWT) algorithm. Video compression is to prefer lossy compression Techniques. The compression scheme has to achieve high compression ratio with maintain the reconstructed video quality.

M. Mary Shanthi Rani, *et al*. [8-9] proposed an effective method for generating vector quantization codebook using mode based k-means clustering for compressing images, which achieved good compression ratio and quality as well [8]. They proposed another method that focused on compressing medical images with different codebook sizes for region of interest and non-region of interest using vector quantization method. The proposed method achieves high compression ratio without compromising the quality of reconstructed ROI image.

There are various compression methods have been proposed on vector quantization and residual vector quantization for image compression. A novel approach of medical image compression combining Haar-Wavelet Transform (HWT) and Residual Vector Quantization (RVQ) technique has been proposed and this method achieves high compression ratio than similar medical image compression methods without compromising the image quality that is mandatory for medical diagnosis [10]. An improved method of fractal image coding using residual vector quantization has been proposed for further enhancing the quality of a compressed image [11].

III. Proposed Method (DCT-DWT)

Video compression using Hybrid scheme of transform techniques are effective to produce high quality of video. This paper investigates an improved video compression combining DCT-DWT and Arithmetic coding for achieving high compression ratio without comprising the video quality.

The proposed method is divided into three phases. The first phase finds the difference between two input frames using motion compensation and estimation techniques. The second phase generate compressed image for motion estimation frames applied DCT-DWT transform and Arithmetic encoding. The third phase residual reconstructed video for compressed image using Arithmetic decoding.

In the first phase, Input video is converted to number of frames. Motion Compensation selected two frames such as current frame and reference frame. The selected frames are converted into binary format and find the difference between these two frames is found out using Mean absolute difference in Eq. (1).

$$MAD = \frac{1}{N^2} \sum_{i=0}^{N-1} \sum_{j=0}^{N-1} | C_{ij} - R_{ij} | \quad (1)$$

where, N is the side of the macro bock. C_{ij} and R_{ij} are the pixels being compared in Frame1 and Frame2. Block matching method is used for motion estimation techniques which find a best match within the area on two frames in the motion vectors in a frame.

In the second phase, motion estimation frame is first converted in to [32x32] blocks. Each block is then transformed individually. The 32 x 32 block is converted into 16 x 16 after one level DWT and discarding all the coefficients except the LL (i.e. LH, HH, and HL). The second level of the 2D DWT is applied on the LL coefficients, and this yields an [8 x 8] block after further discarding all the LH, HH, HL coefficients and preserving only LL. The DCT is applied on this block. This transformation by DCT produces lossy compression as the quantization is applied on the DCT coefficients. DCT coefficients are further compressed using Arithmetic coding for better compression.

In the decoding phase, the decoded image blocks are subjected to inverse DCT and inverse DWT respectively. Then motion compensation is performed between similar blocks of every two consecutive frames. Furthermore, the order of frame sequence is checked using motion estimation. Finally, all the frames are combined to form the video.

Algorithm for proposed method (DCT-DWT)

Phase I: Encoding Process

Step 1: Read the input video.
Step 2: Convert the video into number of frames in the '.png' format.
Step 3: Find the difference between input (frame1 and frame2) frames using motion compensation and estimation techniques.

Phase II: DCT-DWT Transform

Step 1: Divide the frames into n x n blocks.
Step 2: Apply DWT-DCT transform on the motion compensated frames
Step 3: Quantize using the standard quantization matrix.
Step 4: Compress the resulting co-efficient using Arithmetic encoding.

Phase III: Decoding Process

Step 1: Read the compressed image.
Step 2: Apply arithmetic decoder to the compressed stream of blocks.
Step 3: Apply Inverse DCT applied in the image blocks.
Step 4: Apply Inverse DWT to the resulting image block.
Step 5: Perform the motion compensation between two blocks of every frames.
Step 6: Check the order of frame sequence using motion estimation.
Step 7: Convert the reconstructed frames into video.

Flow Diagram Proposed Method

The encoding and decoding process of the proposed video compression method is depicted in Fig.3 and Fig.4.

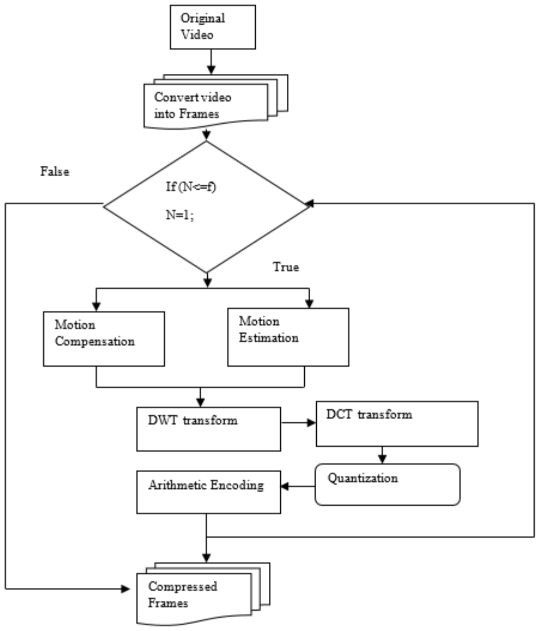


Fig.3 Encoding process of proposed method

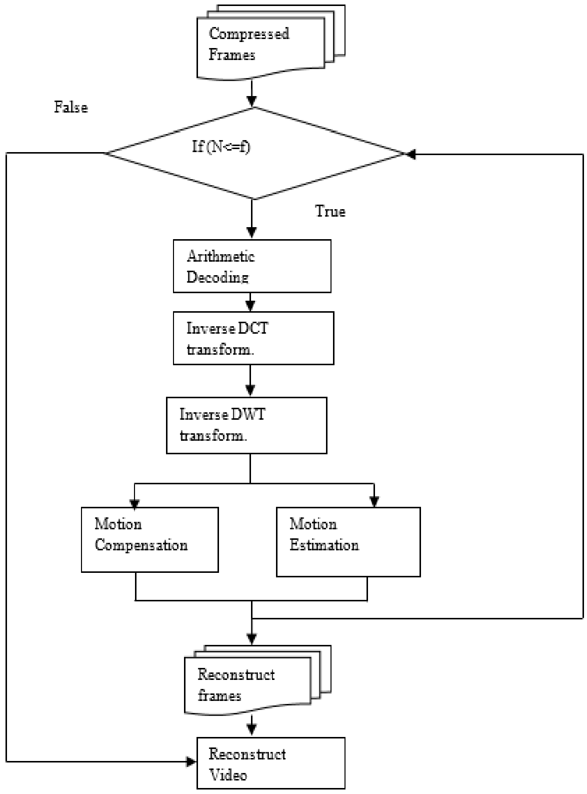


Fig.4 Decoding process of proposed method

IV. Experimental Results and Discussion

In this section, the experimental results of the proposed method using Xholophone.avi, Horse.avi and Dog.avi video files are tabulated in table 1. The performance of the proposed methods has been tested using Peak signal noise ratio (PSNR) and Compression ratio (CR).

A. PSNR (Peak Signal-to-Noise Ratio):

PSNR is calculated for degradation of video after the compression. PSNR is ratio between the maximum possible power of a signal and the power of corrupting noise.

$$PSNR = 10 * log \frac{255^2}{MSE} \tag{2}$$

B. MSE (Mean Square Error):

The MSE represents the increasing squared error between the compressed and the original video. The mean square error is the average of the squared errors between actual and estimated readings in a data sample.

$$MSE = \frac{1}{m * n} \sum_{i=0}^{M-1} \sum_{j=0}^{N-1} \| I(i,j) - K(i,j) \|^2 \tag{3}$$

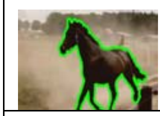
C. CR (Compression Ratio):

The compression ratio is used to find the ratio between the original video and the compressed video encoder which is measured by Eq. (4).

$$CR = \frac{\text{Compressed Video Size}}{\text{Original Video Size}} \tag{4}$$

Table1 results clearly demonstrates the superior performance of the proposed method in terms of PSNR and compression ratio.

Table 1: Performance Analysis of the Proposed Method

Input Video Frame	**Video File Name**	**Performance Metrics**	
		PSNR(db.)	***Compression Ratio***
	Xholophone.avi	**55.21**	**83.52**
	Rhino.avi	**60.64**	**74.29**
	Horse.avi	**36.52**	**75.58**
	Dog.avi	**43.39**	**98.59**
	Car.avi	**41.63**	**83.46**

The Xholophone.avi video compressed using the proposed DCT and DWT algorithm achieved high compression ratio of 83.25 and PSNR value 55.21. Similarly, Rhino video achieved compression ratio of 74.29 and PSNR value of 60.64. Highest compression ratio of 98.59 is achieved for dog video file with moderate PSNR value of 43.39db.

The performance of the proposed method is also compared with similar video compression techniques like, Innovative Video Compression Technique using Discrete Cosine Transform (DCT) [4], Video Compression System for Online Usage Using DCT [6], Hybrid DCT-DWT Algorithm [7].

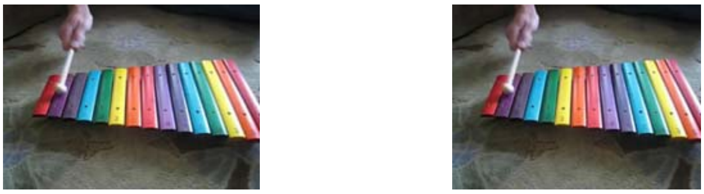
Table 2 shows the comparative analysis results of Existing three video compression methods using transforms such as DCT-DWT and the proposed method.

Table 2: Comparative Analysis of DCT –DWT method

Methods	**Video file Name**	**PSNR(db.)**		**Compression Ratio**	
		Existing	***Proposed***	***Existing***	***Proposed***
Method [4]	Car.avi	20.78	**41.63**	77.6 %	**83.46%**
Method [6]	Rhino.avi	34.95	**60.64**	71.3%	**74.29%**
Method [7]	Xholophone.avi	36.71	**55.21**	77.66%	**83.52%**

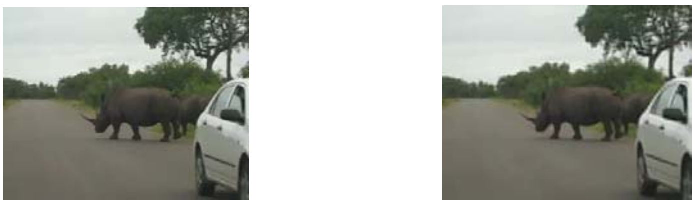
From Table 2, it is obvious that the proposed method outperforms similar method by achieving double PSNR value and g

Visual representation of the proposed method using three videos such as Xholophone.avi, Rhino.avi, Horse.avi are shown in Fig.5 and Fig.7. The proposed method of video compression achieved high quality image without degradation which compared with the original image.



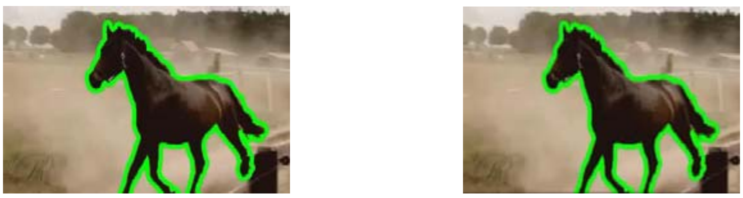
(a) **(b)**

Fig.5 Original and reconstructed frame using proposed method for Xholophone.avi



(a) **(b)**

Fig.6 Original and reconstructed frame using proposed method for Rhino.avi



(a) **(b)**

Fig.7 Original and Reconstructed Frame using Proposed Method for Horse.avi

V. CONCLUSION

In this paper, a novel method for compressing video has been proposed by combining DCT and DWT along with motion compensation and estimation. Experimental results are proved that the proposed method is efficient in terms of achieving high PSNR and compression ratio. In future, this method can be applied for compressing 3D video and web streaming application as well.

REFERENCES

[1] Dhaval R. Bhojani and Dr. Ved Vyas Dwivedi, "Innovative Video Compression Technique using DWT-DCT" 1st International Conference on Emerging Technology Trends in Electronics, Vol.2, pp. 218-224, 2012.

[2] T. Bernatin and G. Sundari, "Video Compression Based on Hybrid Transform and Quantization with Huffman Coding for Video Codec", International Conference on Control, Instrumentation, Communication and Computational Technologies (ICCICCT) , pp.452-456, 2014.

[3] L.Escalin Tresa and Dr. M. Sundararajan "Video Compression Using Hybrid DWT-DCT Algorithm", International Journal of Emerging Technology and Advanced Engineering, Vol.4, Issue7, pp.918-922, 2014.

[4] S.S. Wadd and S. B. Patil, "Video Compression Using DCT", International Journal of Advanced Research in Computer Science and Software Engineering, Vol. 4, Issue 9, pp.394-398, 2014.

[5] Shubham Gupta and Dr. Amit Joshi, "VLSI Implementation of 3D Integer DCT for Video Coding Standards" 2nd International Conference on Next Generation Computing Technologies, Vol. 2, pp.660-664, 2016.

[6] S.B. Midhun Kumar and Mr.A.Jayakumar, "Video Compression System for Online Usage Using DCT" International Journal of Trend in Research and Development, Vol. 2(4), ISSN 2394-9333, pp.67-72, 2015.

[7] S.V.Phakade and Harish Patil "Video Compression Using Hybrid DCT-DWT Algorithm" International Research Journal of Engineering and Technology (IRJET), Vol. 03, pp.2758-2761, 2016.

[8] K. Somasundaram and M. Mary Shanthi Rani "Mode Based K-Means Algorithm with Residual Vector Quantization for Compressing Images" International Conference on Control Computation and Information System (Springer- Verlay (CISIZ)), pp. 105–112, 2011.

[9] M. Mary Shanthi Rani and P. Chitra, "Region of Interest based Compression of Medical Images using Vector Quantization ", International Journal of Computational Science and Information Technology (IJCSITY), Vol.4, No.1, pp. 29-37,2016.

[10] M.Mary Shanthi Rani and P. Chitra, "A Novel Hybrid Method of Haar-Wavelet and Residual Vector Quantization for Compressing Medical Images", International Conference on Advances in Computer Applications (ICACA),Vol.1, pp.321-326, 2016.

[11] M. Mary Shanthi Rani and P. Chitra, "An Improved Fractal Image Compression using Residual Vector Quantization for Compressing Medical Images", Proceedings of International Conference on Frontiers in Engineering, Applied Sciences and Technology, Vol. 3,pp. 86-90, 2017.

[12] Thazni Aziz and D. Raveena Judie Dolly " Motion Estimation and Motion Compensated Video Compression Using DCT And DWT", International Journal of Emerging Technology and Advanced Engineering Vol. 2, Issue 12, pp.667-671, 2012.