Video Compression Technique Using Transform Based Methods

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Abstract—Technology has met an unprecedented growth that resulted in a myriad of web applications, specifically involving multimedia data transmission. This places a great demand on network bandwidth for effective transmission through the internet. Fortunately, the challenge is addressed by compressing data with robust data compression algorithms. Video is composed of sequential frames or images and its compression can be achieved by compressing individual frames through elimination of redundant and relevant information. Transform based methods are highly preferred for transmitting quality images or video frames. In this proposed work, two transform methods like Discrete Cosine Transform(DCT) and Discrete Wavelet Transform(DWT) methods have been implemented to enhance the quality of frames with high compression ratio.

Keywords- Video Compression, Transform Coding Methods, Arithmetic Encoding.

I. INTRODUCTION

Generally, videos are represented as a collection of sequential frames which is used in multimedia applications. A video file occupies a vast storage of memory to store and transmit the file. The purpose of image compression is to create a unique solution to recover a file without compromising a image quality [1]. A video compression is termed as a reduced size of frames by omitting unwanted data. The general representation of video is given in Fig.1 and Fig.2.

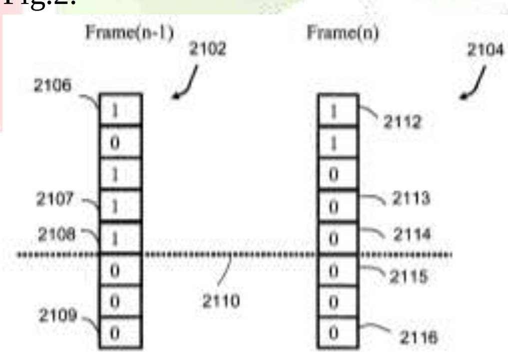


Fig.1. Splitting Video into Frames

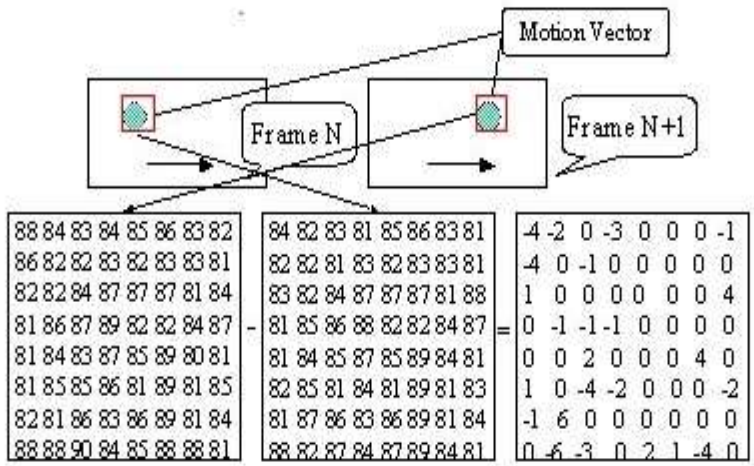


Fig.2. Motion Estimation

Compression techniques are classified into two lossy and lossless based on the quality of the reconstructed data. In lossless compression technique, there is no loss of data and the original image is perfectly reconstructed[2]. In contrast, lossy compression can lose some of information which is not relevant and necessary to the original image data [3-4]. There are some popular techniques to exhibit the performance of lossy image compression. Transform coding is one of the best representations of lossy compression coding which minimizes quality degradation [5-6]. Normally, transform based methods are used to enhance the quality of reconstructed image with comparable range of original image. Discrete Cosine Transform(DCT) and Discrete Wavelet Transform(DWT) are some popular methods that are commonly used in video compression for compressing sequence of frames in an effective manner. The DCT has high energy compaction property and requires less computational resources. The main advantage of applying DCT is to achieve high compression while maintaining the quality.

A. *Discrete Cosine Transform (DCT)*

The process of DCT requires less computational complexity which is similar to the Karhunen - Loeve Transform (KLT). Also, the DCT technique has a high energy compaction when compared to DFT, DST, WHT and DWT. Therefore, the usage of DCT is highly preferred in image and video compression. However, for higher compression, it introduces blocking artifacts and the outline effects in reconstructed image. There are some limitations involved in DCT technique.

- Blocking artifacts: Blocking artifacts is a kind of distortion which appears due to higher compression. 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 irregularity that looks like a contour map for particular images having gradually shaded areas.

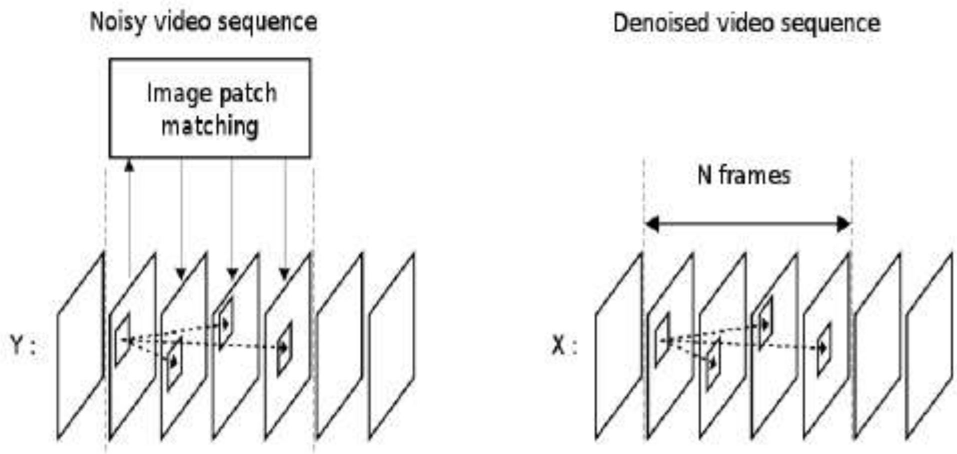


Fig.3. Representation of DCT Process

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].

Fig.4. Video Frames using DWT Process

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 quantizer is a non-linear device that chooses representative values for range 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 frames very effectively by losing information, but only information associated with less important image details.

D. Motion Compensation

A video is represented as a sequence of frames and two successive frames of a video sequence often have slight 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).

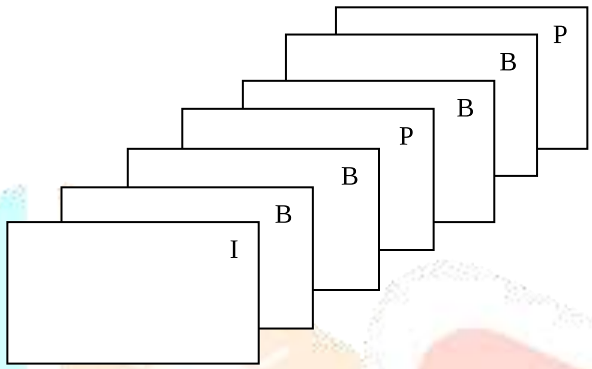


Fig 5: Frame Sequence Order

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 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. It 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 WORK

There are various existing methods proposed using DCT and DWT techniques. Thazni Aziz et al. [8] proposed a motion estimation and motion compensated video compression techniques using DCT and DWT methods. A.M.Raid et al. [9] presented a survey on JPEG compression technique using DCT method. The author has proved that DCT method is used for full-colour still image applications and describes all the components. K.Mahesh and K.Rajalakshmi [10] proposed a lossless video compression using DCT and DWT techniques in which they have used object position change finding algorithm to get video process in real time and lossless decompression. S.V.Phakade *et al.* [11] presented a video compression using hybrid DCT-DWT algorithm. Chander mukhi et al. [12] describes about an improved image compression using hybrid transform of DWT-DCT algorithm. Shiwangi and Sanjeev Kumar [13] proposed a detail description and analysis of image compression algorithm using DCT, DFT and DWT transforms.

Several methods have been proposed on integrating DCT and DWT methods for image compression[14-16].

III. PROPOSED METHOD

Hybrid scheme of transform coding techniques using video compression algorithm are proposed for enhancing the quality of video. This paper investigates an improved video compression algorithm which has combined DCT-DWT and Arithmetic coding for achieving high compression ratio without comprising the video quality.

Mainly, the proposed method is classified into three phases. In the first phase, the difference between two input frames using motion compensation and estimation techniques are obtained. The second phase has generated the compressed image for motion estimated frames by applying DCT-DWT transform and Arithmetic encoding. The third phase conducts the decoding process by applying arithmetic coding for the compressed stream of blocks.

In the first phase, input video is converted into number of frames. Motion Compensation selects two frames such as current frame and reference frame. Then the selected frames are converted into binary format and the difference between two frames which refers the Mean Absolute Difference is calculated using 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 size of the macro block. 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 into [32x32] blocks. Each block is transformed individually. The [32 x 32] block is converted into [16 x 16] while the first 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.

A. Proposed Algorithm (DCT-DWT)

Phase I:
Encoding Process

Step 1: Read the input video.
Step 2: Convert the video into number of frames in the specified 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 input frames into n x n blocks.
Step 2: Apply DWT-DCT transform on the motion compensated frames.
Step 3: Quantize the image blocks using the standard quantization matrix.
Step 4: Compress the resulting co-efficient using Arithmetic encoding.

Phase III:
Decoding Process

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

B. Proposed Flow Diagram

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

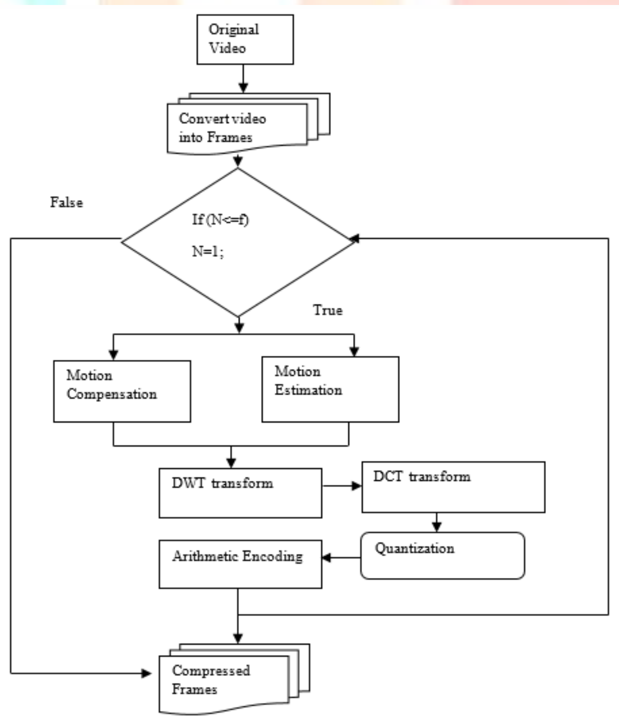


Fig.6 Encoding process of proposed method

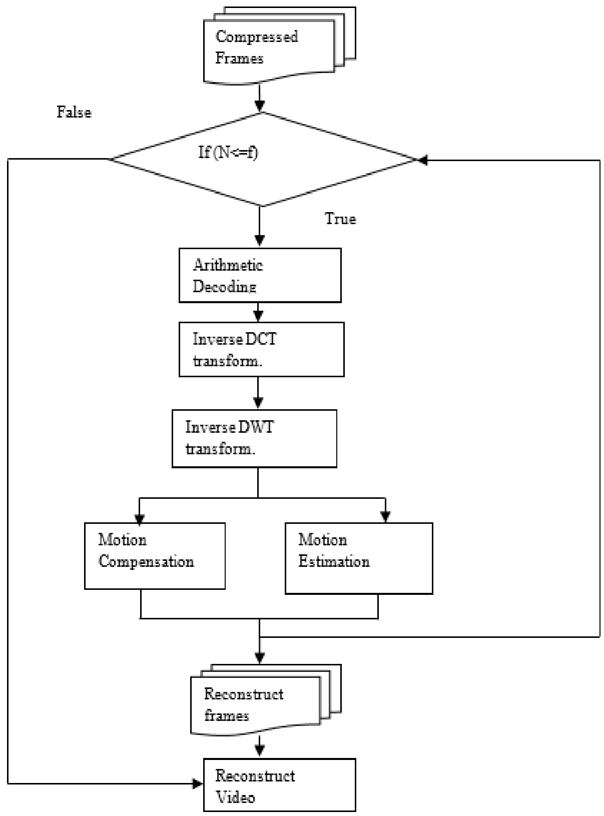


Fig.7. Decoding process of proposed method

IV. RESULTS AND DISCUSSION

In this section, the experimental results of the proposed method are examined using test videos like Xholophone.avi, Horse.avi and Dog.avi which are tabulated in table 1. The performance of the proposed methods has been evaluated using Peak Signal Noise Ratio (PSNR) and Compression ratio (CR).

PSNR (Peak Signal-to-Noise Ratio)- The degradation of video quality is measured using PSNR value.

$$PSNR = 10 * log \frac{255^2}{MSE} \qquad (2)$$

MSE (Mean Square Error)- The mean square error is the average of the squared errors between actual and estimated readings in a data sample.

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

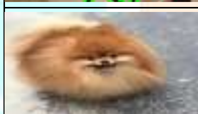
CR (Compression Ratio):

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

$$\text{CR} = \frac{\text{Compressed Video Size}}{\text{Original Video Size}} \qquad (4)$$

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 Method	***Proposed Method***	***Existing Method***	***Proposed Method***
Method [14]	Car.avi	20.78	41.63	77.6 %	83.46%
Method [15]	Rhino.avi	34.95	60.64	71.3%	74.29%
Method [16]	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 good compression ratio as well.

Visual representation of the proposed method using three videos such as Xholophone.avi, Rhino.avi and Horse.avi are shown in Fig.5 and Fig.6. The proposed method of video compression achieved high quality images without degradation when 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

This paper presented a novel method for compressing video integrating DCT and DWT with motion compensation and estimation. Experimental results demonstrate that the proposed method is efficient in terms of achieving higher PSNR and compression ratio. In future, this method can be applied for compressing 3D video and web streaming application as well.

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