# Compression of Video Data for Transmission Over Low Bandwidth Network

Dr. Dhirendra Mishra
Associate Professor,
Computer Engineering Department
MPSTME, SVKM's NMIMS University
Mumbai, India

Ms. Poonam Gupta
Assistant Professor,
Computer Engineering Department
MPSTME, SVKM's NMIMS University
Mumbai, India

***Abstract*** **- Video is the most useful and most appealing approach to represent some information. The problem with such kind of media is its large size which affects the efficiency. Video compression is required to save the storage space. The combined approach of removing spatial and temporal redundancy will return the high degree of compression ratio.**

**This paper first targets the techniques to remove the spatial redundancy from each frame of the video. Here various transform techniques (i.e. DCT, Haar, Walsh, Kekre, and Wavelet of all transforms) are implemented and analyzed with respect to different performance evaluation parameters like Mean Square Error (MSE), Compression Ratio (CR). Then it deals with the temporal redundancy removal where the differences between the consecutive frames are found and then the above transform techniques are used in difference matrix of the frames. It also focuses on other methods like half toning and sub-band decomposition for removing the spatial redundancy from the frame of a video.**



**Keywords – video compression, transforms, half toning, subband decomposition**

## I. INTRODUCTION

A picture can say more than a thousand words and multiple images also called as frames are comprised together to form a video which speaks the whole action. Hence, Digital video is used in an increasing number of applications including Security/surveillance, digital television, DVD, video telephony, cellular media, Internet video streaming, digital video camcorders, and personal video recorders.

Video compression is a necessary tool for these applications and a growing number of video codec (compression/decompression) industry standards and proprietary algorithms are available to build it practical to store and transmit video in digital form.

Compression standards are growing to make use of advances in algorithms and take benefit of continued increases in available low-cost integrated circuits such as digital media processors. There are differences exist in the compression standards and within an implementation of standards based on optimizations for the primary requirements of the target application [1, 4].

The big advantage of digital video is that it can be compressed for reduced bandwidth applications including transmission over cable TV, satellite and Internet-based networks. The compressed video is mainly useful for reducing storage requirements. The advantages of video and image compression for preservation of network bandwidth are well known. There have been a number of video compression standards present today.

Though storing or transmitting the image or video data can cost more than a million words but this is not always a problem because now computers are capable enough to handle large amounts of data. However, it is often desirable to use the limited resources more efficiently. For instance, digital cameras often have a totally unsatisfactory amount of memory and the internet can be very slow. In these cases, the importance of the compression of images is greatly felt.

Raw or uncompressed video needs a lot of data to be stored or transmitted which is the main problem with digital video.

The aim for image and video compression is to represent (or encode) a digital image or sequence of images in case of video using as few bits as possible at the same time as maintaining its visual appearance. Compression often involves trade-offs between the quality of the image required and other needs of the application.

There are mainly two primary standards organizations driving the definition of image and video compression standards. The International Telecommunications Union (ITU) is focused on telecommunication applications and has created the H.26x standards for video telephony. The Internal Standards Organization (ISO) is more focused on consumer applications and has defined the JPEG standards for still compressing its size i.e. reducing the no. of bits required per frame for transmission over the network. The various methods explored for the purpose of compressing video are listed in Fig. 1.2.

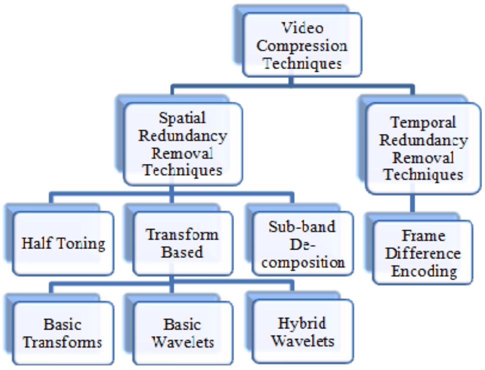


Fig. 1 Video Compression Techniques implemented

The above listed methods are compared with the help of Mean Square Error (MSE) to know the quality affected of the frames and in turn the video and Compression Ratio (CR) to get the amount of data compressed or saved.

This paper first explains the various video compression methods and then result obtained followed by conclusion and future work.

## II. METHODS FOR COMPRESSION OF VIDEO DATA

### *A. Half tone Operators for High Data Compression*

To compress a huge like video data, the combination of lossy half tone and lossless Run-Length-Encoding (RLE) technique is used so as to obtain low-bit rate video data transmission.

Half toning process reduces visual reproductions to an image that is printed with only one colour of ink, in the form of dot. These tiny half tone dots are blended into smooth tones by the human eye, this term is referred to as optical illusion or in other words, human being integrates en-tire image and do not read image pixel by pixel. In this way half tone process converts 8-bit into 1-bit pixel information. This is the great advantage of half toning those results into 8:1 CR in a single iteration. Kekre and et. al has described the half toning algorithm in [5] using various half tone operator.

Fig. 2 shows the original frame and compressed frame i.e. output after applying half toning operator on original frame. Since Half toning gives higher compression so distortion of the original frame is quite higher which can be seen in the output frame.

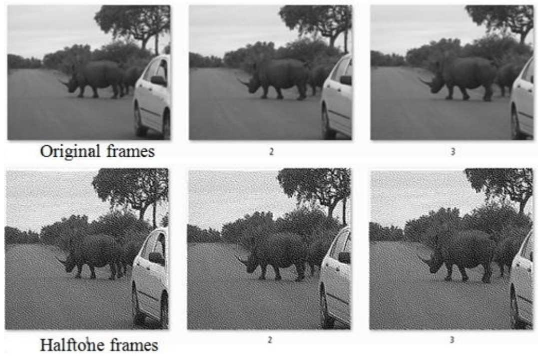


Fig. 2 Original and Compressed Frame using Half tone operator

### *B. Image compression using transforms techniques*

Transform methods can be used for compression of images and video frames. It transforms the input data into a format to reduce inter pixel redundancies in the input image. Transform coding techniques use a reversible, linear mathematical transform to map the pixel values into a set of coefficients, which are then quantized and encoded. The key factor behind the success of transform-based coding schemes is that many of the resulting coefficients for most natural images have small magnitudes and can be quantized without causing significant distortion in the decoded image [6,7]. For compression purpose, the higher the capability of compressing information in fewer coefficients, the better the transform; for that reason, the Discrete Cosine Transform (DCT) and Discrete Wavelet Transform (DWT) have become the most widely used transform coding techniques.

The basic principle behind transform coding can be described as follows. On the encoding side, an image to be compressed is first divided into $N \times N$ non overlapping blocks in the usual raster scanning order, that is, from left-to-right, top-to-bottom. Then, a particular unitary transform of size $N \times N$ is applied to each pixel block. Next, the transform coefficients in each block are quantized individually to different number of bits depending on the significance of the coefficients. The block of quantized coefficients is then scanned to serialize for transmission or storage. As there may be a large run of zeros in each quantized coefficient block, run-length coding (RLC) of different run-lengths is found and then entropy coded for transmission or storage. On the decoding side, the operations are reversed. First, the compressed bits are entropy decoded to separate the individual transform coefficients. [2-4] Next, the coefficients are de-quantized, arranged in a rectangular block followed by inverse unitary transform. Finally, the decompressed blocks are arranged to form the image. Fig. 3 is a block diagram description of a transform coder.

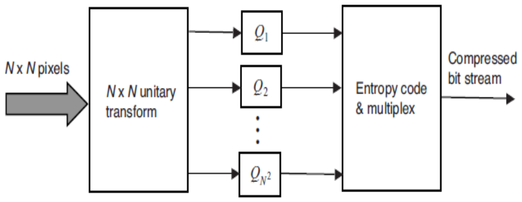

Fig. 3 Block Diagram of transform Coder [10]

Here standard transforms have been applied for the purpose of compression and then Wavelet transform matrix were generated using algorithm mentioned in [8-12] and used instead of a standard transformation matrix. After the simulation it was found that wavelet gives better compression compared to its respective original transforms.

## C. *Sub-band Decomposition*

The spatial redundancy of each frame can be reduced by multiple folds using sub-band decomposition. The sub band decomposition uses the concept of simple averaging and differencing technique to reduce the size of the image and in turn the bits required to send the frame as a data signal.

The original image is decomposed into a lower resolution version and a pair of detail coefficients. It uses the way used to compute the wavelet transform by recursively averaging and differencing coefficients, filter Bank and image can be reconstructed to any resolution by recursively adding and subtracting the detail coefficients from the lower resolution versions. The process of sub band decomposition is similar to wavelet in which we get four components of an image. The structure of sub band decomposition is given in Fig. 4.

<table>
<tr><td>LL</td><td>HL3</td><td rowspan="2">HL2</td><td rowspan="3">HL1</td></tr>
<tr><td>LH3</td><td>HH3</td></tr>
<tr><td colspan="2">LH2</td><td>HH2</td></tr>
<tr><td colspan="3">LH1</td><td>HH1</td></tr>
</table>

Fig. 4 Structure of Wavelet Decomposition [16]

Here, each filter is 2D with the subscript indicating the type of filter (HPF or LPF) for separable horizontal and vertical components. By using these filters in one stage, an image is decomposed into four bands. There exist three types of detail images for each resolution: horizontal (HL), vertical (LH), and diagonal (HH). The operations can be repeated on the low low (LL) band using the second stage of identical filter bank [13].

The transformation of the 2D image is a 2D generalization of the 1D wavelet transformed. It applies the 1D wavelet transform to each row of pixel values. This operation provides us an average value along with detail coefficients for each row. Next, these transformed rows are treated as if they were themselves an image and apply the 1D transform to each column. The resulting values are all detail coefficients except a single overall average co-efficient. In order to complete the transformation, this process is repeated recursively only on the quadrant containing averages.

The sub-band decomposition uses the following steps to get a lower resolution version of the original image or frames:

Step 1) Start with the matrix *P* representing the original image or frame.

Step 2) Compute the transformed matrix *T* by the operation averaging and differencing (First for each row, then for each column).

Step 3) Take the LL band of transformed matrix T for transmission.

Step 4) Apply zooming process on received matrix to get the original resolution of an image.

The Fig. 4 (a) shows original image, 4 (b) is showing 1-level decomposition and 4 (c) is the zoomed version of decompressed image.

Fig. 4 (a) Original Frame

Fig. 4 (b) Result of frame with 4 band(LL,LH,HL,HH) of Sub-band decomposition

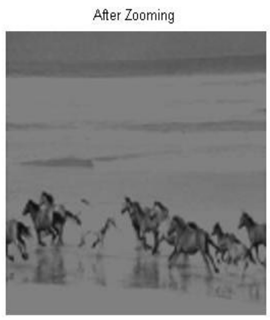


Fig. 4 (c) Zoomed version of LL co-efficient

*D. Temporal redundancy removal using difference of frame and encoding*

In video compression the temporal i.e. inter frame redundancy removal part is most important as huge amount of data i.e. pixels are similar between consecutive frames. The idea behind compression is to save time and the number of bits sent between images by taking the difference between them instead of sending each frame again. With video streaming and storage becoming so popular this is a very useful tool to have. In this, the differences of consecutive frames are calculated and then compression techniques are applied on the difference frame and in turn encoding mechanism can be applied for further compression.

As the transform techniques take more time for complex calculation increasing the time complexity and hence the delay in transmission of frames on low bandwidth networks. So video data can also be compressed without using transforms and directly applying various coding mechanisms on difference i.e. residual frame. In this section two methods are proposed for compression of video data.

*a) Proposed Method 1 (Difference + Encoding RLE)*

Here to remove temporal redundancy we can use simple differencing method to make the maximum pixel value of difference matrix as 'zero' and in that difference matrix further RLE coding can be applied to remove the bits require per pixel further. The block diagram given in Fig. 5 gives the process of differential encoding technique on video.

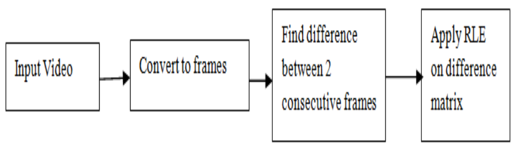


Fig. 5 Block diagram for RLE encoding on differential frame to remove temporal redundancy

The detailed process of implementation is explained with the help of below algorithm:

1. Take input video and convert it into frames.
2. For i =1 to Total_Frames
   - Find difference between two consecutive frames and store the result into R.
   - Apply RLE on R and maintain two matrix OccurenceMatrix and PixelIntensity.
   - Divide PixelIntensity value by 4 to reduce the bits required for pixel representation further.
   - Transmit OccurenceMatrix and PixelIntensity matrix.
3. At the receiver end, apply reverse process to get the original frames.
4. Create video from decoded frames.

*b) Proposed Method 2 ( Difference + Encoding of data for transmission )*

In this method of temporal redundancy coding we take the difference of two frames and that difference frames are transmitted after applying encoding technique on that. Here one method has been proposed for encoding process to decrease the no. of bits transmitted per frame. The detailed algorithm is given below:

1. Take input video and convert it into frames.
2. For i = 1 to Total_Frames
   - Find difference between two consecutive frames and store the result into R.
   - Store '0' element of difference matrix R as '0' and other elements as '1' in new Matrix say R_bin. Also store actual data of R into matrix R_data.
   - Transmit R_bin and R_data.
3. At receiver end, apply reverse process to get the original frames.
4. Create video from decoded frames.

Further the above algorithm is explained with the help of small matrix of 3 x3 and is depicted in Fig. 6.

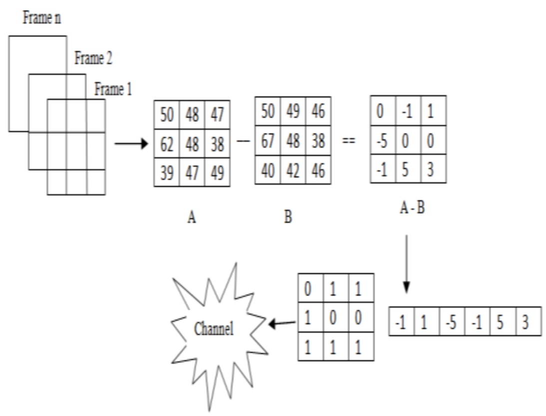


Fig. 6 Block diagram for transmitting differential frame to compress data size

## III. RESULT & DISCUSSION

The video compression techniques can be evaluated as per following performance evaluation parameters:

- Compression Ratio (CR): is evaluated to know the amount of data compressed in the video and total amount of disk saving achieved.
- Mean square Error (MSE): is evaluated to know the quality of video affected.

The comparative results of applying video compression techniques to remove redundancy are given in Table I. The techniques are compared on the basis of average MSE of the first 300 frames of sample video of frame size 256 x 256 and Compression ratio.

Table I Comparative result of various techniques based on compression Ratio and MSE

| Methods | Compression Ratio (CR) | Mean Square Error (MSE) |
|---|---|---|
| Half Toning (A) | 8 | 17456.2 |
| Half Toning + RLE (B) | 16.62 | 17456.2 |
| Transform Based with 25% reduction in size (C) | 1.33 | 7.7 |
| Transform Based with 50% reduction in size (D) | 3 | 1.29 |
| DCT Wavelet Transform Based with 25% reduction in size (E) | 1.33 | 2.56 |
| DCT Wavelet Transform Based with 50% reduction in size (F) | 3 | 1.15 |
| Frame Difference+RLE (Method 1) (G) | 2.4 | 6.2 |
| Frame Difference + Encoding (Method 2) (H) | 1.8 | 5.2 |

The Fig. 7 and Fig. 8 show the comparative result of numerous video compression techniques based on performance evaluation parameter CR and MSE respectively. The methods name of Fig. 7 and Fig. 8 can be referred from Table I.

These figures show that Half toning method gives the best result having a higher compression ratio whereas transform based methods gives lower compression ratio but if compared with Mean Square Error than the result is vice versa. So there is always a trade-off between these two parameters i.e. we try to increase the compression ratio than the MSE value has to go down and we will get degraded frame or image.

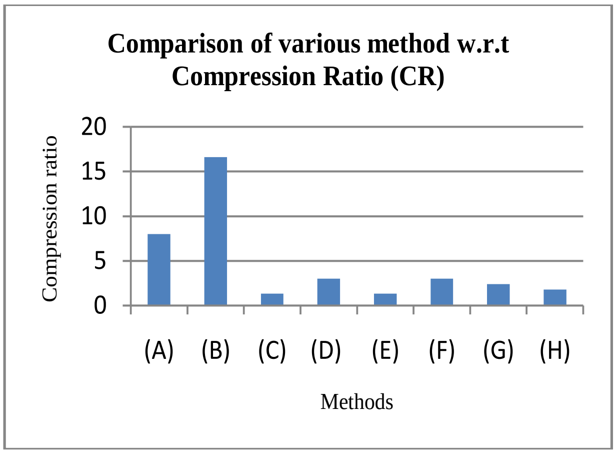


Fig 7. Comparison of video compression methods w.r.t. Compression ratio (CR)

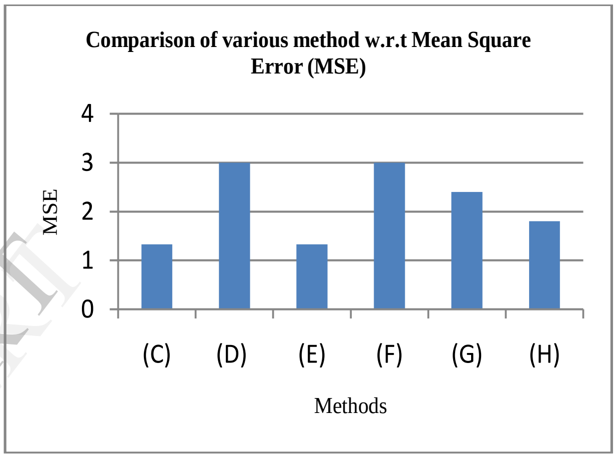


Fig. 8. Comparison of video compression methods w.r.t. Mean Square Error (MSE)



## IV. CONCLUSION AND FUTURE WORK

Generally, video signal has high temporal and spatial redundancies. The spatial redundancy is removed using various methods such as MJPEG, transform, Wavelet transform and hybrid transforms along with sub-band decomposition. Out of all studied and implemented methods the traditional DCT transform only gives better result compare to others.

In this a new video compression techniques have been explored which exploits objectively the temporal redundancy. Then the spatial removal methods are applied on the difference matrix of consecutive frames to tackle the temporal redundancy. But to decrease processing complexity new methods were explored in which only encoding techniques were applied to the differential frames of video. These proposed techniques may be more useful in case of low motion video where changes in two consecutive frames are not very high.

The motion compensation and estimation techniques can be explored further for higher degree of compression.

REFERENCES

[1] Aroh Barjatya, "Block Matching Algorithms For Motion Estimation", DIP 6620 Spring 2004 Final Project Paper.

[2] Jasmeet Kaur, Rohini Sharma, "A Combined DWT-DCT approach to perform Video compression base of Frame Redundancy", International Journal of Advanced Research in Computer Science and Software Engineering, Volume 2, Issue 9, September 2012 ISSN: 2277 128X.

[3] Thazni Aziz, D. Raveena Judie Dolly, "Motion Estimation and Motion Compensated Video Compression Using DCT And DWT", International Journal of Emerging Technology and Advanced Engineering Journal, Volume 2, Issue 12, December 2012)

[4] Marc Alzina, Wojciech Szpankowski, "2D-Pattern Matching Image and Video Compression: Theory, Algorithms, and Experiments", IEEE TRANSACTIONS ON IMAGE PROCESSING, VOL. 11, NO. 3, MARCH 2002.

[5] Dr. H.B. Kekre, Dr. Tanuja K. Sarode, Sanjay R. Sange, Pallavi Halarnkar "New Half tone Operators for High Data Compression in Video-Conferencing", The 2012 International Conference on Software and Computer Applications (ICSCA 2012), IPCSIT vol. XX (2012) © (2012) IACSIT Press, Singapore.

[6] Jaya Krishna Sunkara, 2E Navaneethasagari, 3D Pradeep, 4E Naga Chaithanya, 5D Pavani, 6D V Sai Sudheer "A New Video Compression Method using DCT/DWT and SPIHT based on Accordion Representation", *I.J. Image, Graphics and Signal Processing*, 2012, 4, 28-34

[7] Ouni, T.; Ayedi, W.; Abid, M., "New low complexity DCT based video compression method," *Telecommunications, 2009. ICT '09. International Conference on* , vol., no., pp. 202,207, 25-27 May 2009 doi : 10.1109 /ICTEL.2009.5158644

[8] Dr. H. B. Kekre, Archana Athawale & Dipali Sadavarti," Algorithm to Generate Wavelet Transform from an Orthogonal Transform", International Journal Of Image Processing (IJIP), Volume (4): Issue (4)

[9] Dr. H. B. Kekre, Archana Athawale & Dipali Sadavarti," Algorithm to Generate Kekre's Wavelet Transform from Kekre's Transform", International Journal of Engineering Science and Technology Vol. 2(5), 2010, 756-767

[10] Scientific & Engineering Research, Volume 4, Issue 10, October-2013 512 ISSN 2229-5518

[11] Dr. H. B. Kekre, Archana Athawale & Dipali Sadavarti, "Algorithm to Generate Wavelet Transform from an Orthogonal Transform", International Journal Of Image Processing (IJIP), Volume (4): Issue (4).

[12] Dr. H. B. Kekre, Archana Athawale And Dipali Sadavarti, " Kekre's Hybrid Wavelet Transform Technique With Dct, Walsh, Hartley And Kekre's Transform For Image compression", International Journal of Engineering Science and Technology, Vol. 2(5), 2010, 756-767

[13] Khalil, Hosam, Amir F. Atiya, and Samir Shaheen. "Three-dimensional video compression using subband/wavelet transform with lower buffering requirements." *Image Processing, IEEE Transactions on* 8.6 (1999): 762-773.