

Very Low Bit-Rate Video Coding by Combining H.264/AVC Standard and Empirical Wavelet Transform

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Abstract: In this paper, a novel video compression approach is proposed for video coding at very low bit-rate with combination of empirical wavelet transform and H.264/AVC standard. The proposed method is used to extract low frequency components in each frame by applying the empirical wavelet transform on each video frame separately. The frames with low frequency are coded by using H.264/AVC codec and high frequency frames are coded by Huffman Coding algorithm. By applying of threshold the low coefficient values are neglected. Experiments of the proposed method show the analysis and better performances in rate distortion. When compared to direct applying of the H.264/AVC standard to all frames, the performances of the proposed method achieved at very low bit rate applications below 16kbts/s. The application of proposed technique video coding includes the video receiving and transmitting over the GSM networks of half-rate traffic channels, video-conferencing and video telephony. The performance analysis shows the efficient and reliable process than the ordinary standard of H.264.

Keywords: Video coding; Huffman Technique; H.264 standard; GSM; Wavelet Transform;

I. Introduction

Nowadays, video delivery and transmission through the bandwidth channels required more bit rate and the application is more demand in world wide. High-definition television (HDTV) and digital video by satellite (DVS) are processed through the high bandwidth application and at low bandwidth through the modems process of transmission to the limit of speed below 56kbts/s is considered. The digital videos are represented with more bits and for transmission the data is too large, so it process is difficult. In order to overcome compression technique is used in the application of digital video for easy transmission through the internet.

In multimedia application compression of video plays a vital role and transmits the data with the available capacity of transmission. It bounded with the standard to support the application of the video related like digital television and conferencing. H.264/AVC is a coding standard to enhance the efficiency and representation of non-interactive and interactive video. It improves the efficiency of rate-distortion and operate the unaccepted artifacts at low bit rate. It improves the code efficiency of the video with the quality [10].

An inter - frame coder is used to provide vulnerable process of propagation of error in the video and used in a particular application of coding. The transmission of frames with error through the channels is processed with the condition. For compression technique more bandwidth is required and its process with high-speed of video coding systems. The performances are analysed by evaluating the frames and provide low cost of computation cost, robustness and low complexity, but suffer with the performances of low compression.

For visual communication, significant performance a video compression system is well-designed and provides an efficient process during transmission of high/low bandwidth. The low bandwidth enables the process of video telephony by a standard connection of telephone with basic quality, but high bandwidth provides high quality performances of video. The basic function of video coding scheme is shown in Fig [1]. The wavelet based coding scheme of video is used to distribute the function of frame separation with the extended source coding application. The conventional of video motion and the compression of frames is performed based on the domain of wavelet transforms. The correlated function of the coding is done by bit plane coding.

In this paper, the proposed video compression technique system required low bit rate to encode and decode the frames of the video. It enhanced the efficiency of application and rate distortion. By combining the H.264/AVC standard and Empirical wavelet transform (EWT) the technique is proposed with very low bit rate.

At the low frequency component the encoding of frames is difficult and process the separation of the frequency level of high and low based on the boundary detection. It provides better accuracy in video quality and detects the values to define the frequency level of the video. Based on curve let filter the detection of boundary value is used to separate coefficient function and perform the wavelet transform for better compression at low level bit rate. The reconstructing process of video frame is done by the inverse of encoding. The encoding and decoding method is preceded by the Huffman coding and H.264 standard.

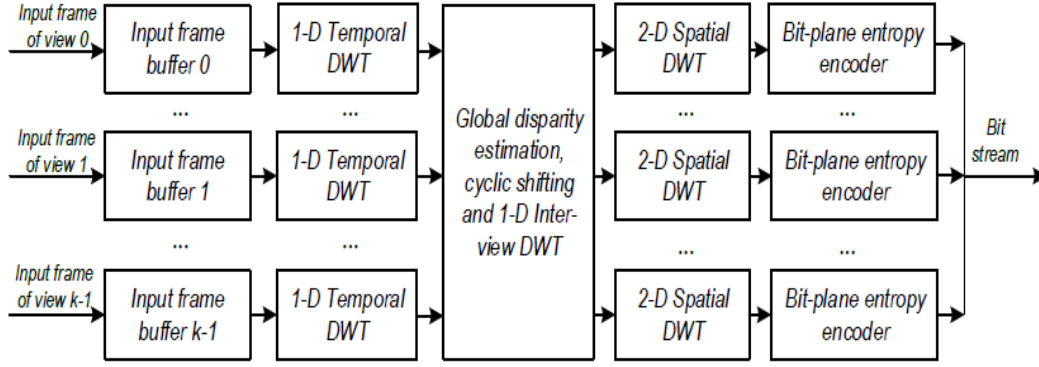


Fig.1: Basic view of Multi view of Video coding scheme

The rest of the proposed method is explained in section wise. In Section II, literature review of wavelet transforms and the video coding is discussed. The architecture of the proposed system of video coding and its explanations are presented in section III. In section IV, discussed about the simulation results and analysis of performances with comparison of proposed and existing system. Finally, conclusion and future work are given in section V.

II. Related Work

In this section, literature reviews related to video coding scheme are discussed. In image and signal processing, Discrete Wavelet Transform (DWT) is used to simulate the method with multi-resolution properties. Also, it is difficult in the management, video coding and control of translation invariance. By colour video coding the video file transmission bandwidth and the storage cost are reduced. The coding is based on a separate sign coding (SSC) to utilize DWT by sub-band coding approach in coefficient amplitude of wavelet [12].

By combining of 2D DWT and the standard of H.264 are used to encode the video sequence at low bit rate. At low frequency each frame of the video is extracted and the frames are coded by H.264/AVC codec [14]. Using Run Length Coding algorithm the high frequency frames are coded and neglect the coefficient, low value by applying threshold [13].

By efficient techniques the depth video is compressed and considered the range of depth data dynamic, artifacts and spatial resolution. Due to changes in boundary signal, the video is compressed by conventional video coding standards and affects the view of synthesized quality. By efficient post processing method coding of depth video is performed based on utilizing the in-loop filter and filtering the mode weight. It reduces the resolution of spatial and dynamic range for efficient decoding to restructure the video. The down/up sampling, coding approaches is used to process at low bit rate [6]. Local optimum solution is computed and estimated by 1D and 2D-DCT for video compression system [7].

The document is scanned by a hybrid pattern matching/transform-based compression method and used to predict the inter frame of video. It generates the coding process by encoder and provides efficient process compressor with high quality. The performances of the encoding achieve better quality. According to the details the signal has decomposed and built adaptive wavelet. The wavelet filter bank is designed to extract the signal at various modes [3].

The tone-mapping scheme is used for efficient coding of bit-depth with perceptual quality. In numerical model, represents the layer bit rate changes and estimate it during dynamic process. It optimizes the issues by adding the scheme and tone-map is compressed directly without RGB domain conversion and saves the bit rates [8].

Conventional hybrid block-based approach enhanced the efficiency of standard coding of video. The coding technique increases the range of transforming block size using quad tree-based partitioning and HEVC techniques improve the efficiency of coding with improvement [2], [5]. By estimation of block-based motion the quality of visual while the artifacts blocking is free from the scheme of wavelet [14]. Empirical Mode Decomposition (EMD) has evaluated the signal performance without a post and pre-processing by computing the data of nonlinear and linear. The performances of the system are evaluated with various parameters [1], [4].

For low-complexity of the coding algorithm of video is based on 3D DWT with source channel joint and error- resilient. It is more robust than the standard in loss of packets. The joint source-channel coding algorithm provides better complexity and quality with power consumption [9], [11].

In this paper, by proposing method the performances of coding the video and transmit and receiving of data at a very low bit rate. By combining standard and Huffman coding with the Empirical Wavelet Transform (EWT) the video coding provide better accuracy and performances in PSNR and bit rate.

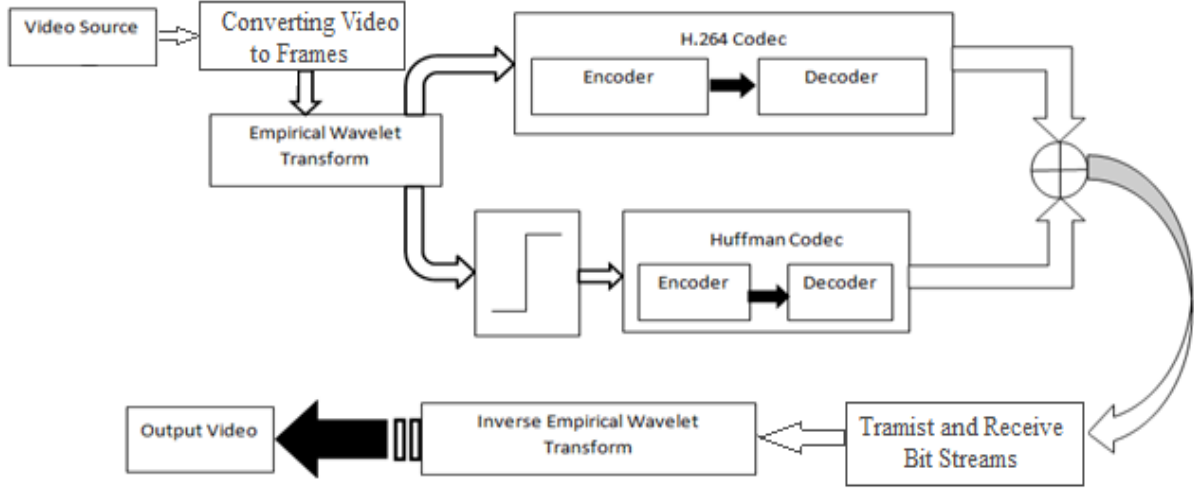


Fig.2: Block Diagram of Proposed system

III. Proposed Work

In this section, a novel approach of video compression is used to encode and decode the video sequences. It combines Huffman codec and H.264/AVC standard with the empirical wavelet transform. The wavelet transform is used to compress the video frames. The main aim is to provide the enhanced performances and reliable access at very low bit rate. This application is used to decompose the video frame and its details into high and low frequency level. For decomposition of video sequence the empirical wavelet transform is applied. Then the frames are divided into high frequencies and low frequencies based on level and details of frames. By using the standard H.264 the sequenced frames with low frequencies are encoded, but high frequency frames are encoded by using a Huffman Codec algorithm. Fig [2] shows the block diagram of the proposed system.

In the proposed system, the video is converted to frames for easy compression of video with high speed and shows in 2D visual. Then the video stream is decomposed by the Empirical Wavelet Transform for the separation of frames based on the level of frequencies. The background and structure details are available in low frequency component and the parameters like edges, details of frames and border are available in high frequency components. The decomposed video stream is carried out through Empirical Wavelet Transform.

The ordinary H.264 codec is coded the object structure and low frequency sequence components at low bit rate. But in proposed system the low frequencies are extracted by utilizing the Empirical wavelet transform and by using H.264 codec the extracted details are encoded. The visual quality is based on the parameters of the codec standard and the factor of quantization. The low frequencies have a smaller dimension and quantizing it by more bits.

By utilizing the motion compensation types increases the reconstructed video quality.

The remaining video frames are high frequency components which encoded by the Huffman codec. In decomposition process, smaller quantities are neglected after the procedure of thresholding by initializing zero values. So, zero will be repeated frequently in a sequence to compress but if not apply more than one time then the encode process will be afterward. The procedure of optimum source coding is done by Huffman Coding. By applying on a threshold value (T) the rate of compression is increased. Then the value is applied to the high frequency coefficient value of transform ($C_{x,y}$) as given below.

$$C_{x,y} = \begin{cases} C_{x,y}, & |C_{x,y}| < T \\ 0, & \text{otherwise} \end{cases} \quad (1)$$

After the process of EWT the video format is QCIF, the layer of the frames are the chrominance (Cb and Cr) and luminance (Y). The empirical wavelet transform is performed three times to recollect the layers to construct the sequence frame in the video. It generates with less dimensions with the original structure of the video sequence.

The proposed system is processed as per the procedure given below:

1. Function of Pseudo Polar FFT
2. FFT shifting process
3. Boundary detection and Angle detection
4. Average Spectrum Calculation
5. Creation of Filter bank coefficient
6. Creating Angular grids
7. Estimate EWT coefficient values

Generally in an existing system the coefficient of negative is high and encoded by run length. But in proposed system the video sequence separates the components by EWT and find coefficient of it. It performs by implementing curve let filter. It is used to convert the domain from time to frequency. By the proposed system the negative coefficient is less and the negative values are converted to bit for better process of compression.

Pseudo-Polar FFT of Curve let Transform:

$$\mathcal{F}_P(\psi_j)(\omega, \theta) = 2^{-3j/4} W(2^{-j}\omega) V\left(\frac{2^{j/2}\theta}{2\pi}\right) \quad (2)$$

Where, $W(r)$ and $V(t)$ are radial window and angular window width $r \in (1/2, 2)$ and $t \in [-1, 1]$.

The wavelet will classify the components based on the boundary values detection into high and low frequency by using curve let filter. The aim of the

system is to provide low frequency. By the proposed design the combine of frequency have less possibilities. Less than boundary values are low frequency else high frequency. By angular grids the local maxima and minima is estimated to separate the values and provide accurate process of video coding in multimedia application.

The coefficient of the EWT is calculated by the Huffman coefficient in order to increase the compression ratio. The decimal value is decreased to the maximum value range for compression of video to perform at a very low bit rate than the existing system.

In boundary detection, a polar wedge ψ_{nm} (Indices of angular and scalar are n and m) of the radial window Fourier domain, W_n for which $n \neq N_s - 1$ is given below. Polar Coordinate in Fourier Plane is $\Theta^{N_s+1} = \Theta^1 + \pi$ and (ω, Θ) .

$$W_n(\omega) = \begin{cases} 1 & \text{if } (1 + \gamma)\omega^n \leq |\omega| \leq (1 - \gamma)\omega^{n+1} \\ \cos \left[\frac{\pi}{2} \beta \left(\frac{1}{2\gamma\omega^{n+1}} (|\omega| - (1 - \gamma)\omega^{n+1}) \right) \right] & \text{if } (1 - \gamma)\omega^{n+1} \leq |\omega| \leq (1 + \gamma)\omega^{n+1} \\ \sin \left[\frac{\pi}{2} \beta \left(\frac{1}{2\gamma\omega^n} (|\omega| - (1 - \gamma)\omega^n) \right) \right] & \text{if } (1 - \gamma)\omega^n \leq |\omega| \leq (1 + \gamma)\omega^n \\ 0 & \text{otherwise.} \end{cases} \quad (3)$$

and, if $n = N_s - 1$:

$$W_{N_s-1}(\omega) = \begin{cases} 1 & \text{if } (1 + \gamma)\omega^{N_s-1} \leq |\omega| \\ \sin \left[\frac{\pi}{2} \beta \left(\frac{1}{2\gamma\omega^{N_s-1}} (|\omega| - (1 - \gamma)\omega^{N_s-1}) \right) \right] & \text{if } (1 - \gamma)\omega^{N_s-1} \leq |\omega| \leq (1 + \gamma)\omega^{N_s-1} \\ 0 & \text{otherwise.} \end{cases}$$

and a polar window, V_m ,

$$V_m(\theta) = \begin{cases} 1 & \text{if } \theta^m + \Delta\theta \leq \theta \leq \theta^{m+1} - \Delta\theta \\ \cos \left[\frac{\pi}{2} \beta \left(\frac{1}{2\Delta\theta} (\theta - \theta^{m+1} + \Delta\theta) \right) \right] & \text{if } \theta^{m+1} - \Delta\theta \leq \theta \leq \theta^{m+1} + \Delta\theta \\ \sin \left[\frac{\pi}{2} \beta \left(\frac{1}{2\Delta\theta} (\theta - \theta^m + \Delta\theta) \right) \right] & \text{if } \theta^m - \Delta\theta \leq \theta \leq \theta^m + \Delta\theta \\ 0 & \text{otherwise.} \end{cases} \quad (5)$$

The filter bank process of the proposed system is given below.

$$\mathcal{B}^{\mathcal{ER}} = \left\{ \phi_1(\mathbf{X}), \{\psi_n(\mathbf{X})\}_{n=1}^{N-1} \right\} \quad (6)$$

By the proposed system, the performances in PSNR and bit rate are improved than the ordinary mode of standard. Normally during high quantizing of factor loss of information is possible, but in proposed system the losses are avoided when processing between the separations of video and coding by Huffman Coding algorithm.

At very low bit rate the communication process of the proposed system is performed than the default standard mode. By utilizing the channel with a connection of dialup is performing effectively with low capacity. The standard computation complexity of video sequences is directly connected with frames. When comparing between the standard codec and EWT the complexity of codec is negligible, so it provides faster performances than the ordinary codec standard and emerging application with codec standard by improving the system to increase compatible than the existing.

IV. Simulation Results

In this section, the simulation results of the proposed system performances are evaluated and analysed. It revealed the analysis by simulating the method and estimated the PSNR value and speed. When compare to existing system the proposed system required very low bit rate to process and provide better computation. To obtain the results considering two video sequences for comparison. As shown in Fig [3] and Fig [4], the average PSNR of video sequence is estimated for Nvip traffic and Nvipun marked road video. The speed of the proposed method for both sequences is shown in Fig [5] and Fig [6].

Table [1] illustrated the obtained value of video sequence coding PSNR value with the comparison between the proposed system and existing system for Nvip traffic Video Sequence and in Table [2] evaluating the PSNR value with comparison for Nvipun marked road Video Sequence.

The execution speed of the proposed system is compared with the existing system and the obtained results are plotted in Table [3] for Nvip traffic video sequence. Fig [7] shows the original frames of the video sequence and the reconstructed frame of the video after decoding. In Table [4], for the sequence of Nvipun marked road video the execution speed of video compression illustrates the obtained results of the proposed system and the existing system.

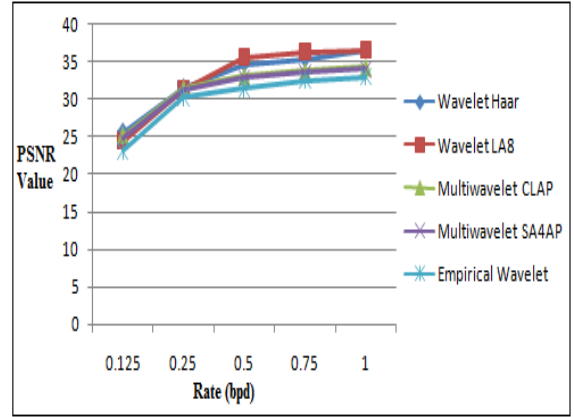


Fig.3: Analysis of PSNR value for Nvip traffic Video Sequence

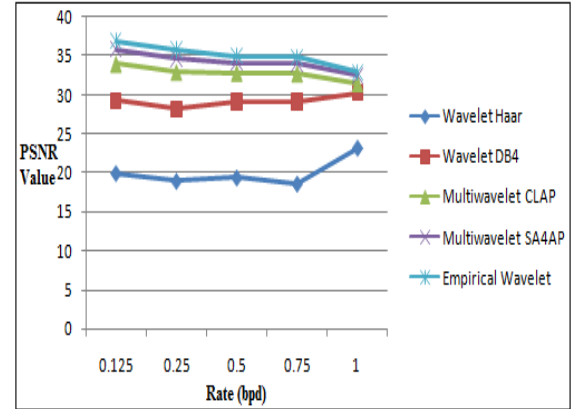


Fig.4: Analysis of PSNR value for Nvipun marked road Video Sequence

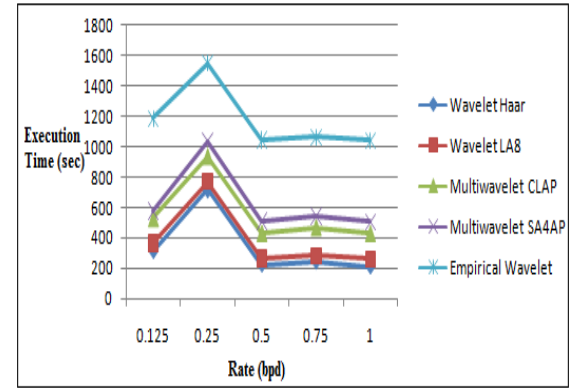


Fig.5: Analysis of Execution speed for Nvip traffic Video Sequence

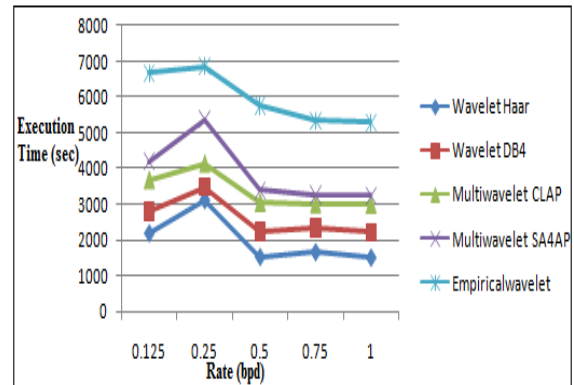


Fig.6: Analysis of Execution speed for Nvipun marked road Video Sequence

Table 1: Analysis of average PSNR value for Nvip traffic Video Sequence

Rate (bpd)	Average PSNR (dB)				
	Wavelet		Multi wavelet		Empirical wavelet
	Haar	LA8	CLAP	SA4AP	
0.125	25.61	24.43	25.17	24.73	23.16
0.25	31.54	31.32	31.37	31.24	30.23
0.5	34.73	35.51	33.05	32.79	31.43
0.75	35.34	36.23	33.71	33.48	32.51
1	36.53	36.41	34.22	33.97	32.88

Table 2: Analysis of average PSNR value for Nvipun marked road Video Sequence

Rate (bpd)	Average PSNR (dB)				
	Wavelet		Multi wavelet		Empirical wavelet
	Haar	DB4	CLAP	SA4AP	
0.125	19.96	18.98	19.41	18.63	23.16
0.25	29.24	28.22	29.12	29.12	30.23
0.5	33.96	32.89	32.78	32.72	31.43
0.75	35.81	34.68	34.15	34.08	32.51
1	36.92	35.77	34.94	34.85	32.88

Table 3: Analysis of Execution time for Nvip traffic Video Sequence

Rate (bpd)	Execution Time (Sec)				
	Wavelet		Multi wavelet		Empirical wavelet
	Haar	LA8	CLAP	SA4AP	
0.125	313.04	716.96	223.78	243.12	211.14
0.25	366.02	768.95	269.34	286.81	265.25
0.5	527.48	931.6	433.18	469.45	430.86
0.75	578.93	1038.1	515.92	545.15	510.59
1	1185.9	1552	1044.1	1057.6	1040.37

Table 4: Analysis of Execution time for Nvipun marked road Video Sequence

Rate (bpd)	Execution Time (Sec)				
	Wavelet		Multi wavelet		Empirical wavelet
	Haar	DB4	CLAP	SA4AP	
0.125	2188.4	3099.7	1540.2	1672.9	1520.84
0.25	2798.1	3478.8	2251.6	2352.5	2241.36
0.5	3695.5	4150.8	3068.7	3029.7	3010.47
0.75	4204.9	5374.4	3396.5	3274.5	3266.44
1	6684.4	6864.3	5760.8	5319.8	5287.74



Original Video Frame 1



Reconstructed Video Frame 1



Original Video Frame 2



Reconstructed Video Frame 2



Original Video Frame 3



Reconstructed Video Frame 3

Fig.7: Results of original video frame and reconstructed video frame

The reconstruction part of the video sequence is performed by inverse process of encoding. By decoding the frames are grouped and constructed as the original image. By inverse of Empirical wavelet transform the encoded frames are reconstructed and

the input to it is from the transmitter and receiver bit stream. Then obtained results of Inverse EWT are finally grouped to reconstruct the frame to provide an output of video sequence; obtained results are shown in Fig [7].

V. Conclusion

In this paper, a novel approach is proposed for video coding by the process of decomposition by Empirical wavelet transform and by combining the H.264/AVC standard and Huffman coding. The performances of the proposed system provide better accuracy and quality; also communicate at very lower bit rate than the existing system. Therefore, it is more reliable and preferable for video coding in real time applications. The transmitting and receiving process is performed with speed and accuracy process without factor loss of video.

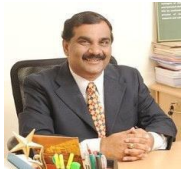
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