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Research paper

HSV, Edge Preserved and Huffman Coding based Intra Frame High Efficient video Compression for Multimedia Communication

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Abstract

High Efficiency Video Coding (HEVC) is another pressure standard for high resolution video content, which just needs 50% of the bit rate of H.264/Advanced Video Coding (AVC) at the same perceptual quality. Be that as it may, the computational intricacy is increments dramatically to adopt quad-tree organized Coding Unit (CU). In this document a new Hue Saturation Lightness (HSV), Edge Preserving and Huffman coding (HC) based intra frame high efficient video compression algorithm is introduced which is named as HSV-EPHC-IFHEVC. To increase the compression ratio of the video frames Huffman and Differential Pulse Code Modulation (DPCM) encodings are used. To improve the de-compressed frame quality in compression Sharpening filter based Edge preserving technique is used. This HSV-EPHC-IFHEVC algorithm provides much better performance compared to existing systems. The performance measurement is in the terms of MSE, PSNR, RMSE and Execution time.

Keywords: *High efficient video compression; Intra frame coding; Hue Saturation Lightness (HSV); Edge Preserving; Differential pulse-code modulation and Huffman coding.*

1. Introduction

Over the most recent couple of years the request of the multimedia administrations i.e., the telecom, transmission and getting the video, sound and other information has expanded [1]. In the new generation Transmission of mixed media sharing is major challenge due to the very higher bandwidth (BW) requirement, the lesser delay is essential because of protocol stack between task and the aftereffect of blunder propagation inside the video succession in case of information parcel misfortunes. To conquer these constraints new video pressure standard Video Coding Experts Group (VCEG) is presented [2]. The prevailing standard for video coding is H.264 [3] and is utilized to convey an extensive variety of video correspondence offices.

Whenever, H.264 necessitates enormously high BW, constructing the transport of High-Definition (HD) video facilities unreasonable. Its successor, H.265 [4], is standardized by the Moving Picture Experts Group (MPEG) in 2012 and is expected to reduce the bit rate characterized to H.264 High Profile by about 50% while maintaining comparable subjective quality [5]. Therefore HEVC is a more practical choice for delivering HD and Ultra HD (UHD) video content to consumers using in digital communication [6]. However, the coding efficiency still cannot meet real time requirements. A gradient based fast IM decision system was introduced [7] to decrease the computational difficulty of H.265, where the distribution of the gradient-mode histogram is engendered to achieve the intra prediction (IP) by using the lesser fragment of the candidate methods.

The firmness act of H.265 is associated with the numerous global standards [8], and parallel effects were reported in the JCT-VC study [9].

The greatest way to calculate the compression enactment is measures the subjective quality as seeming by genuine person viewers. The objective of the particular valuation is quantify [9]. The extent feasible, the bit rate savings for which like subjective quality is achieved for the H.265 test model compared to a similarly configured AVC encoder and decoder. The subjective assessments were conducted using nine test sequences with full HD 1920X1080 and wide VGA (WVGA) 832X480 resolutions at four bit rate/quality points each. Cho et al. [10] utilized Bayes decision rule method for early termination of the coding unit. The statistical values of the previous frames can't improve the IP process performance. Zhang et al. [11] proposed a fast Intra Mode(IM) decision which based on the RD cost estimation.. C.U. Lee et al [12] proposed a method based on the depth level of CU. This can be done by consider the temporal correlation with neighboring Unit. Cus. Shen et al [13] presented a fast CU size decision algorithm according to texture homogeneity and coding information of neighboring CUs. However, when the texture information of the coding area is complex, the coding performance loss is relatively high for the prediction error of CU size selection. From the study of all the existing systems, it is found that they consist of some advantages and disadvantages. In this paper a new HSV, Edge Preserving and HC based Intra Frame High Efficient Video Compression algorithm is introduced (HSV-EPHC-IFHEVC). By using this HSV-EPHC-IFHEVC algorithm which provides much better performance compared to existing systems.

2. HSV-EPHC-IFHEVC System

Block (BLK) based video coding is one of the mostly used compression technique for video. In this HSV-EPHC-IFHEVC system, Video frames are Edge preserved by the help of sharpening filter. The edge sharpened frame is split into coding BLK's. The BLK coding has been classified into two different types such as inter-frame coding technique and Intra-frame(IF) Coding . In this paper Intra-frame prediction coding technique is used for video compression. The block diagram of the HSV-EPHC-IFHEVC system is shown in the Fig.1

Compression: From the block diagram HSV-EPHC-IFHEVC system it is seen that the input video is converted into frames, frame edges are preserved by the help of sharpening filter. The edge sharpened frames are split into coding BLK s (in the size of 16x16, 8x8 and 4x4). Each BLK is transformed by the 8X8 DCT. After the transformation to improve the frame clarity, the video Quantization (Qzn) and Zig-zag scanning is applied. To minimize the compressed bit size minimum values are encoded by the HC and maximum values are encoded by the Difference Pulse Code Modulation. Finally, Huffman encoded bits and DPCM encoded bits are cascaded.

Decompression: For decompression process, inverse process of compressing has been done. Finally the performance of the HSV-EPHC-IFHEVC is measured. The algorithm of the HSV-EPHC-IFHEVC system is shown below

2.1 Algorithm of HSV-EPHC-IFHEVC System

Step 1: Start frame separation.
Step 2: Initialize the Coding Block Tree(CBT) and Prediction Unit(PU) blocks.
Step 3:Start Intra Prediction(IP). From this IP, 35 modes are detected and these modes are combined as 1 output which is given in to the BLK extraction.
Step 4: The blocks are again split as CBT and PU blocks. Then these blocks are given into the DCT, Quantization and Zig-zag scanning.
Step 5: The compressed array of the each blocks are obtained from Zig-zag scanning.
Step 6: The compressed array is again compressed by the Huffman and DPCM encoding. Finally, the outputs from the Huffman and DPCM are cascaded and the cascaded values are stored (i.e., encoded value of frame).
Step7: The decoding is performed by using the encoded Huffman and DPCM values. The decoding process of this video compression is nothing but the reversible process of encoding.

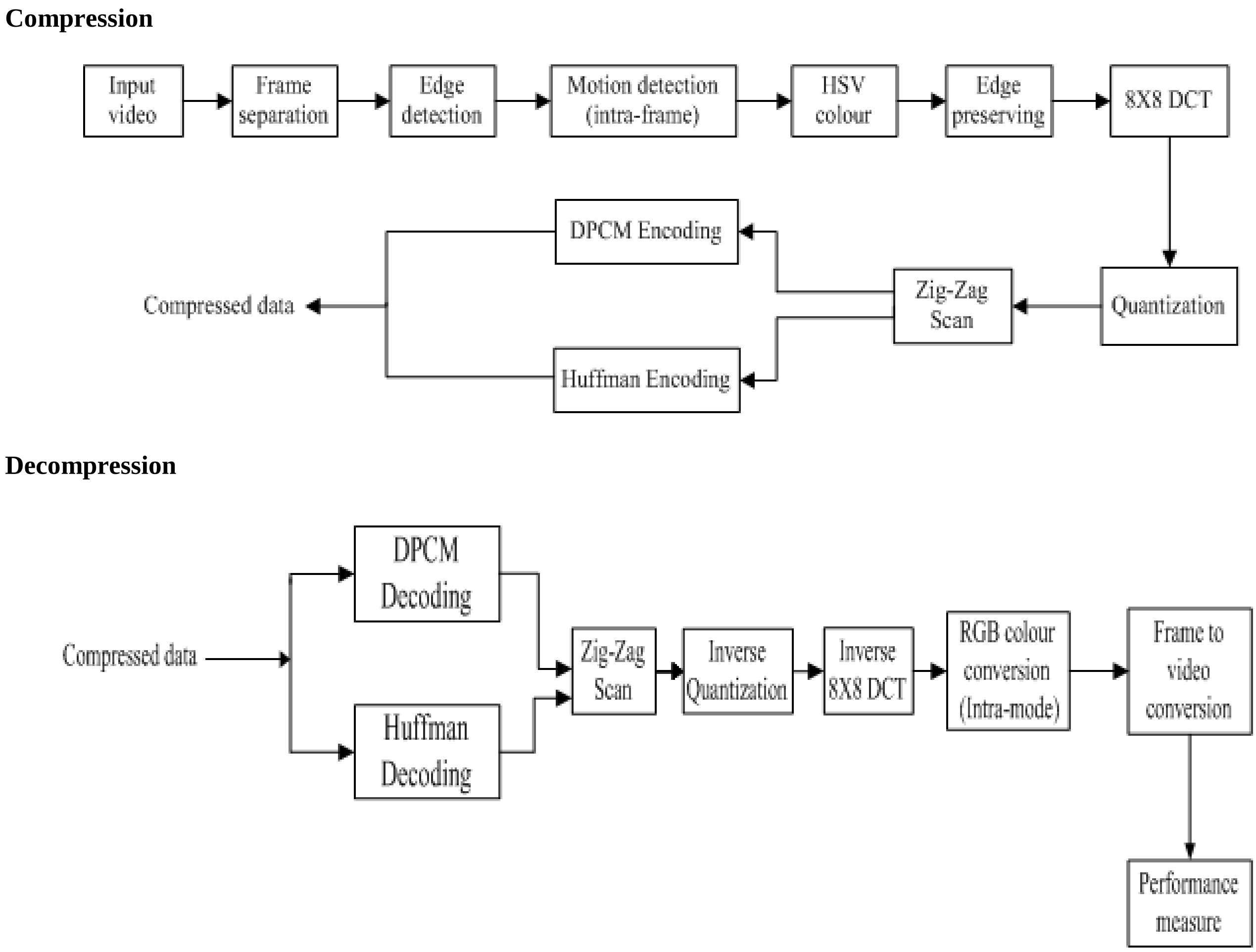

Fig. 1: Block diagram of the HSV-EPHC-IFHEVC system

2.2 Intra Mode Predictions

In MPEG-1 Standard(Std), I-Picture is coded by IF Coding. While using the I-Picture encoding, the spatial redundancy is reduced in the picture with comparing to other pictures. This Intra Mode(IM) coding procedure is same to the JPEG Std. So encoding I-Picture is lesser difficult compared to P-frame and B-frame. Decoding I-Picture is differing procedure of encoding process (EP), so in this segment only EP is described. Earlier going advance, it should be known that the basic CU is a BLK which is an 8X8 matrix. And a macro-BLK consists of 6 blocks: 4 blocks of luminance (Y), one BLK of Cb chrominance, and one BLK of Cr chrominance. The macro-BLK building[14] is shows in the Fig. 2.

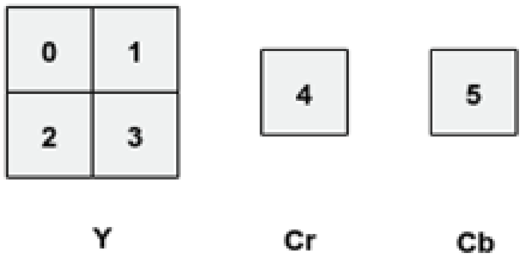

Fig. 2: Macro BLK structure

The Intra Prediction(IP) prognosis is earlier used to decode the boundary models from spatially nearest blocks. In sequence to forecast a new prognosis BLK is PB. The initial image of a video various improvements have been familiarized in H.265 in the IP module because of the greater size of pictures, the collection of maintained coding BLK size (BS) has been greater than before. A Planer mode (PM) considers the continuity at BLK edges is preferred. using this the directionality is improved. The Intra Mode(IM) coding is an effective method to transmit the data for each BLK based on the different directional modes. H.265 funds a huge variety of BS, so it requires consistency across all BS. The initial image at each clear unsystematic access point in a video coded [15]. The Table-1 show the various prediction, IP modes with their corresponding index.

Table 1: IP mode

IP Mode	IP Mode index
PM	M 0
DC Mode	M 1
AM	M 2 to 34

2.2.1 Angular Prediction

The angular prediction progression is functioning of spatial domain. There are 33 different directions are supported in Angular Mode(AM) of HEVC and these AM's are indexed from 2 to 34 in intra coding. The directions from AM is covered the angles of images related to horizontal ,near-diagonal and near-vertical. A displacement parameter of an each is denoted as d, where the measure of d demonstrates the numeric part that is the pixel's removal communicated in 1/32 pixel divisions of exactness, The V and H are indicated the vertical and level directionalities respectively [16]. The modes ten and twenty six are known as unadulterated H forecast and unadulterated vertical expectation individually. The AM extrapolates the fragments from the reference models are derived from mode 10 to mode 26. This prediction achieves less complexity because of its directional value. The fragments located (FL) in a row are represented as extra FL When the direction selected is among 2 and 17,and it is located in the left Column which is extended into left innuendo column. The FL which are at the left column are concentrated as FL in the above row, when the direction selected is among 18 and 34, is and it is extended into the best insinuation push. In the two cases the sections are concentrated and it has negative records. Once the insinuation section are known, each piece is anticipated by demonstrating its situation into the innuen-do parts and applying the favored expectation course. Fragment prediction equation for vertical modes i.e., AM's 18-34

$$
\begin{aligned}
P_{m,n} &= ((32 - w_n) * R_{i,0} + w_n * R_{i+1,0} + 16)\rangle\rangle 5 \\
c_n &= (n * d)\rangle\rangle 5 \\
w_n &= (n * d)\,\&\,31 \\
i &= m + c_n
\end{aligned}
\quad (1)
$$

Fragment prediction equation for horizontal modes i.e., AM's 2-17:

$$
\begin{aligned}
P_{m,n} &= ((32 - w_m) * R_{i,0} + w_m * R_{i+1,0} + 16)\rangle\rangle 5 \\
c_m &= (m * d)\rangle\rangle 5 \\
w_m &= (m * d)\,\&\,31 \\
i &= n + c_m
\end{aligned}
\quad (2)
$$

In this equations ((1) and (2)), $R_{i,j}$ denotes the innuendo fragment and $P_{m,n}$ denotes the fragment to be predicted, whereas m,n are the spatial coordinates. The sub pixel location is between $R_{i,0}$ and $R_{i+1,0.}$ c_m and c_n denoted pixel parameters corresponding to m and n coordinates.
w_n denotes the parameter related to the weighed prediction, 'i' indicates the innuendo fragments index, '>>' named a bit shift operation to the right and & represents AND logical operation. The limits c_n and w_n be subject to manage in concentrated mode and c_m and w_n depend only on m manage for H approaches [17].

2.2.2 Planer Mode

The planer mode is similar to the H.264/MPEG-4 AVC, it is called as a mode 0. The PM algorithm is recommended to the discontinuities along the structure of 2-D signal borderline. The continuities along the BLK edges is preserved by HEVC. By assuming surface with a smooth gradient, the number of PB fragment is calculated. These gradient are derived from the borderline fragment of neighboring blocks.
Fragment prediction equation for PM

$$
\begin{aligned}
P^{V}_{x,y} &= (N - y) * R_{x,0} + y * R_{0,N+1} \\
P^{H}_{x,y} &= (N - x) * R_{0,y} + x * R_{N+1,0} \\
P_{x,y} &= (P^{V}_{x,y} + P^{H}_{x,y} + N)\rangle\rangle(\log_2(N) + 1)
\end{aligned}
\quad (3)
$$

In this eqn.(3), x and y named location of fragment. N stands for total amount of fragment. V and H are for vertical and horizontal respectively. R stands for reference fragment.

2.2.3 DC Mode

The DC mode is also identical to the AVC DC mode and it is named as a mode 1. In larger frequency factors, this DC mode provides coarse prediction Incase of finely textured areas it is not effective. An authority fragments average is equal to the each fragment of the PB.

2.3 Discrete Cosine Transform (DCT)

In MPEG-1 8*8 DCT helps to alter at 8*8 pel BLK to another 8*8 BLK. the energy value of the image is concentrated on top-left corner.

$$
F(u,v) = 1/4C(u)C(v)\sum_{x=0}^{\tau}\sum_{y=0}^{\tau} f(x,y)\cos((2x+1)u\pi/16)\cos((2y+1)v\pi/16) \quad (4)
$$

$$
u, v, x, y = 0,1,2\ldots7
$$

$$
c(j) = \frac{1}{\sqrt{2}},\ j = 0
$$

$$
c(j) = 1,\ j\rangle 0
$$

Inverse two-dimension 8x8 DCT transform

$$
F(x,y) = 1/4\sum_{u=0}^{\tau}\sum_{v=0}^{\tau} C(u), C(v)F(u,v)\cos((2x+1)u\pi/16)\cos((2y+1)v\pi/16) \quad (5)
$$

2.4 Quantization

Quantization(Qzn) is to reduce the range of amounts to a single small value, so that we can use less no. of bits to represent a large amount. For example, we can round a real to an integer. In MPEG-1, use a matrix called quantizer (Q[m,n]) to define Qzn step. Each and Every time when a pels matrix (X[m,n]) with the same size Q[m,n] comes, use Q[m,n] to divide X[m,n] to get Qzned matrix $X_q[m,n]$.
Quantization Eq.:

$$X_q[m,n] = Round\left(X[m,n]/Q[m,n]\right) \tag{6}$$

Inverse Quantization Eq:

$$X'[m,n] = X_q[m,n] * Q[m,n] \tag{7}$$

Inverse Qzn is to reconstruct original value. But we can see Qzn eqn. uses Round ( ) function to get a nearest integer value, so that remodeled value will not be the same as primary value. The characteristics among primary value and remodeled value from Qzned value is also named the Qzn error. In general if we carefully design Q[m,n], visual quality will not be damaged.

2.5 Zig-zag scan

Quantization afterwards most AC attitudes are in the form of zero, by using zigzag scan which can gather even more consecutive zeros.

2.6 Huffman Coding

Huffman Coding (HC) is recommend in 1952 by Huffman. HC is the lossless data compression technique and minimum redundancy method. The HC idea is to assign variable range codes to input characters, lengths of the assigned codes are based on the frequencies of corresponding characters. Huffman's greedy technique looks at the occurrence of each character and it as a binary string in an optimal way. The method accomplishes its aim by allowing character to vary in range. Shorter codes are assigned to the most intermittently used character, and protracted codes to the symbols which appear less intermittently in the string. Code word range are no protracted fixed like ASCII. Code word range vary and will be shorter for the more intermittently used characters [15].

2.7 Differential Pulse-Code Modulation

DPCM is an encoding technique, which transfers an analog data to a digital data. The analog data is tested and then the characteristics between the actual model value and its predicted value is quantized. A predicted value of the actual model is based on the value of the previous model or the values of the previous models [16]. DPCM is also known as Digital pulse modulation, its working in the Prediction algorithm.

3. Results and Discussion

The HSV-EPHC-IFHEVC method was successfully implemented by using the online available data sets. The HSV-EPHC-IFHEVC system was analyzed with the help of MATLAB stimulator software version 2018a. The entire work is done by using I7 system with 8 GB RAM. The performance of the HSV-EPHC-IFHEVC method was measured by the terms of PSNR, RMSE, MSE and Elapsed time. In this HSV-EPHC-IFHEVC method process is explained with ant_maze.avi video. The ant_maze.avi video features are given in the Table-2.

Table 2: ant_maze.avi video features

Duration	3.366 sec
Bits per pixel	24
Frame rate	30
Height	340
Width	480
Video format	RGB24
Number of frames	101

Fig. 3: ant_maze video framer

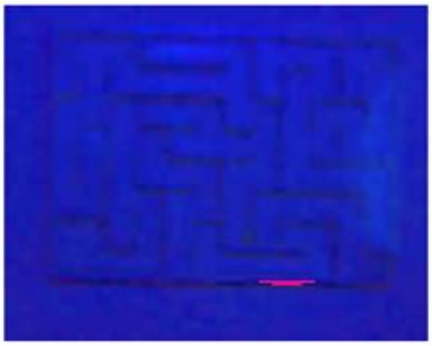

Fig. 4: ant_maze video HSV converted frame

The input video frames are separated and are shown in Fig.3. The separated video frame is converted into the Hue Saturation Lightness (HSV) format which is shown in Fig.4. HSV frame planes are separated, each plane is separately processed.
The plane separated video frame is edge preserved by the sharpening filter, which improves the quality of frame at the time of image decompression. The edge preserved sharpening filter frame is shown in the Fig.5.

Fig. 5: Edge preserved sharpening filter frame

Edge preserved filter sharpens the frame BLK which is separated as shown in Fig.5 encodes by the help of inter and intra prediction. The index positions of all blocks are stored. Encoded blocks are transformed by the DCT. DCT transferred blocks are normalized by the Qzn matrix. Normalized matrix is scanned by the zigzag scan, which provides the array output for that block. All blocks are processed and it is saved as an array. From the block, array's are collected and cascaded for Encoding Process. The cascaded array maximum values are collected and encoded by the DPCM Encoding. Cascaded array minimum values are collected and are encoded by the Huffman coding. Finally both the DPCM Encoded data and Huffman encoded data are cascaded which is compressed data.

In the decompression, compressed data is considered as an input data which is separated into two arrays such as maximum value array and minimum value array. Minimum value array is given to the Huffman decoding and maximum value array is given to the DPCM decoding which is decoded by the respective technique. After that decoded values are cascaded. That cascaded array is given to the inverse zig-zag scan which provides matrix output. Inverse Qzn and inverse DCT are then applied. By using this inter and intra, encoded image is reconstructed with the help of index values. Finally the performance is measured for all frames in terms of PSNR, MSE, RMSE and execution time. For the performance evaluation some other Videos are also considered. The features for those videos are shown in the Table 3.

Table 3: Different input video features

File name (.avi)	Walk1	Walk2	VIP Warn signs	VIP mosaicking
Duration (s)	2.0667	2.9200	9.9000	4.7333
Bits per pixel	24	24	24	24
Frame rate	15	25	30	15
Height	260	180	360	240
Width	260	144	180	320
Video format	RGB24	RGB24	RGB24	RGB24
Number of frames	31	73	297	71

3.1 Mean Square Error

The definition of an MSE differs according to whether one is describing an estimator or a predictor. The mathematical representation of Image MSE is shown in Eq 8..

$$MSE = \frac{1}{PQ}\sum_{m=0}^{P-1}\sum_{n=0}^{Q-1}[I(m,n) - J(m,n)]^2 \qquad (8)$$

Where 'I' is the original frame and 'J' is the decompressed frame

3.2 RMSE

The RMSE is the standard deviation of the residuals prediction error. The mathematical representation of RMSE is given in Eq. 9

$$RMSE = \sqrt{MSE} \qquad (9)$$

3.3 PSNR

PSNR, is used to find the quality of image based on the difference between pixels of two images. It is used to define the quality of rebuilt picture compared with original picture. PSNR is defined as given in Eq.10

$$PSNR = 10\log_{10}\left(\frac{Max_I^2}{MSE}\right) \qquad (10)$$

Table 4: Different videos for HSV-EPHC-IFHEVC system performance evaluation

File name (.avi)	Walk1	Walk2	Vipwarnsigns	vipmosaicking
Sample frame				
PSNR (dB)	27.67163	40.26690	35.87158	36.95420
MSE	110.12487	61.65320	169.72192	133.07718
RMSE	10.33801	7.8512	13.0246	11.5154
Elapsed time (s)	350.9787	191.0416	333.518	370.833

Table 5: Performance evaluations of different videos using existing systems

File name (.avi)	Walk1	Walk2	Vipwarnsigns	vipmosaicking
PSNR (dB)	23.9470	19.978	20.1669	18.274
MSE	126.41	165.85	150.02	101.088
RMSE	11.22	12.87	12.24	10.05
Elapsed time (s)	430.422	341.20	354.445	383.117

The performance of the HSV-EPHC-IFHEVC system for different input videos is shown in the Table-4. The HSV-EPHC-IFHEVC system performance is also compared with the existing system [21] which is implemented and tested. The performance evaluations for existing system videos are shown in Table-5.

The PSNR comparison of the existing system [21] and HSV-EPHC-IFHEVC system is shown in the Fig.6. Compared to the existing system, HSV-EPHC-IFHEVC system provides much better PSNR rate. The Elapsed time comparison of the existing system [21] and HSV-EPHC-IFHEVC system is shown in the Fig.7. Compared to the existing system the HSV-EPHC-IFHEVC system requires less Elapsed time.

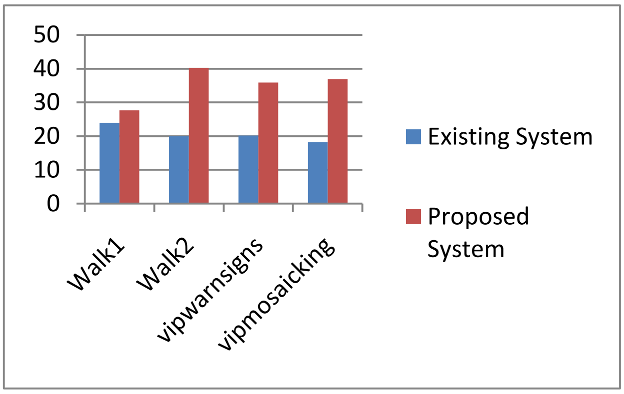

Fig. 6: PSNR comparison of the existing system and HSV-EPHC-IFHEVC

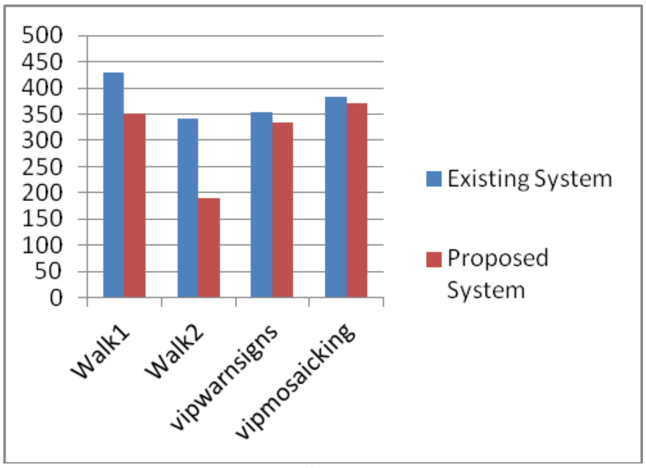

Fig. 7: Elapsed time comparison of the existing system and HSV-EPHC-IFHEVC

4. Conclusion

In this document a novel Huffman and DCPM encoding based intra frame HSV-EPHC-IFHEVC technique is introduced for High efficient video compression. To improve the decompressed frame quality, compression sharpening filter based Edge preserving technique is used. The experimental results show that the HSV-

EPHC-IFHEVC technique provides better presentation in the terms of PSNR, and Implementation time compared to the existing system. In the future work some optimization techniques may be used to minimize the execution time.

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