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Performance evaluation of entropy coding for MPEG-4 video codec

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Abstract: This Paper deals with the Evaluation, Analysis and Algorithm of Context Adaptive Binary Arithmetic coding (CABAC) MPEG-4 Video Codec.MPEG-4 is an ISO/IEC video coding standard which supports highly interactive multimedia applications as well as traditional applications. It includes many advanced functionalities such as interactivities, scalabilities and error resilience. The growing popularity of MPEG-4 in the field of animation and interactive movies was the main motivation to include it in this work. This paper investigates the effect of CABAC Entropy coding scheme that is a crucial parameter for the performance of MPEG-4 video coder. In this paper Algorithm for Context Adaptive Binary Arithmetic coding (CABAC) is proposed for MPEG-4 Video Codec. The compression efficiency of CABAC is 8-12% better as compared to CAVLC and it can be up to 30% better when compared to other entropy compression methods.

Keywords: CABAC, Entropy Coding, PSNR, QCIF and SSIM.

I. INTRODUCTION

The entropy encoder converts a series of symbols representing elements of the video sequence into a compressed bit stream suitable for transmission or storage. An arithmetic encoder converts a sequence of data symbols into a single fractional number and can approach the optimal fractional number of bits required to represent each symbol [1,2]. A variable-length encoder maps input symbols to a series of code words (variable length codes or VLCs). Each symbol maps varying length but must each contain an integral number of bits. Frequently-occurring symbols are represented with short VLCs whilst less common symbols are represented with long VLCs. Over a sufficiently large number of encoded symbols this leads to compression of data.

II. INTRODUCTION TO MPEG-4 VIDEO CODEC

MPEG-4 is a state-of-art video coder with many advanced features, which were not available in its predecessors such as MPEG-1/2. MPEG-4 combines some typical features of other MPEG standards, but aims to provide a set of technologies to satisfy the needs authors, service providers and end users. It enables much functionality potential accessible on a single terminal and higher levels of interaction with content. MPEG-4 achieves these goals by providing standardized ways to support: coding, composition, multiplexing and interaction[3,4]. The key feature of MPEG-4 is decompose a video frames in different layers of video object plane (VOP). The block diagram of a MPEG-4 video coder is shown in Figure 1.

III. CONTEXT-BASED ARITHMETIC CODING (CABAC)

Figure 2 shows the graphical representation of the CABAC decoding algorithm as per the H.264 Video Standard. Our system begins decoding the bit stream once it receives the "Start" signal from the 'Host' or driver where it initializes the Context Memory only before the first macroblock of the slice.

If current Macroblock is not the first, the system prefaces the information from the Top/Left Neighbors required by the current macroblock, and stores it into the local memories of the system. After parameter initializations, the system begins decoding the various Syntax Elements from the H.264 coded bitstream in the order as specified by the standard[5-9].

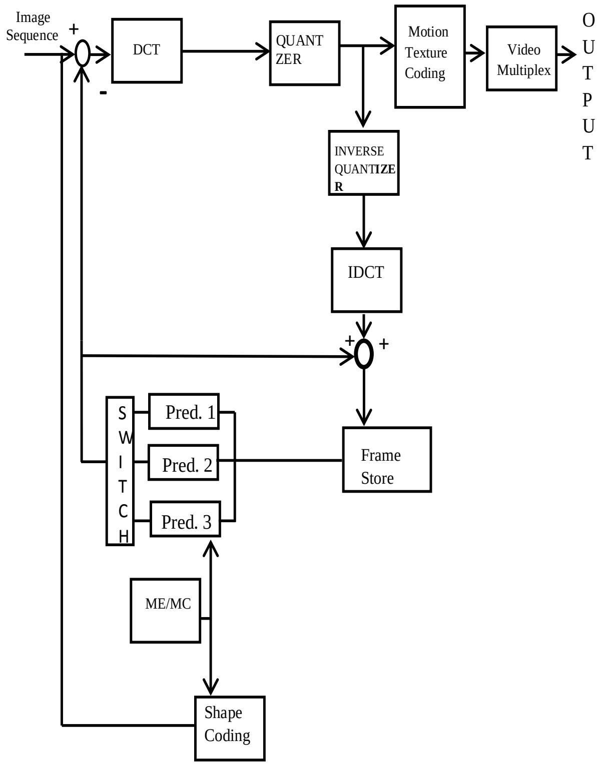

Fig.1 Block diagram of MPEG-4 coder
Where,
DCT - Discrete Cosine Transform
IDCT - Inverse Discrete Cosine Transform
ME/MC- Motion Estimation/Motion Compensation
Pred. - Prediction

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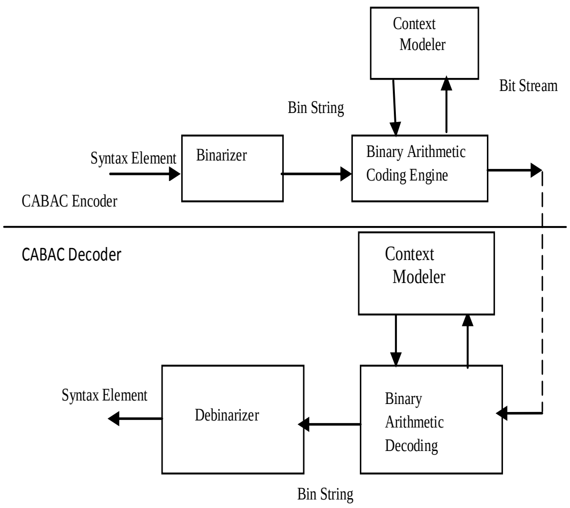

Fig. 2: Block diagrams of CABAC codec of H.264/AVC

For 'Skip' macroblock the system bypasses all decoding processes and begins decoding the next macroblock [10-14]. Once the decoding of all present syntax elements is completed for the required macroblock, this information is stored for future use as neighbor information.

The macroblock information is also then packaged according to required output format and sent to an output buffer. This process of decoding the Syntax Elements for each macroblock continues till the end of slice is reached.

SIMULATION, IMPLEMENTATION DETAILS AND RESULTS OBTAINED

Table 1 gives the summary of results obtained in this work regarding the performance of MPEG-4 codec. Video coding using less number of frames can be used in applications such as video conferencing & video telephony.

$$MSE = \frac{1}{XY}\sum_{x=1}^{X}\sum_{y=1}^{Y}[i(x,y)-e(x,y)]^2 \quad \text{……….. (1)}$$

Where, i (x, y) = Intensity of input pixel (for each Y, U, V)
e (x, y) = Intensity of output pixel (for each Y, U, V)
The PSNR for entire video sequence is defined in terms of average PSNR $Average\,PSNR = \frac{i}{t}\sum_{i=1}^{t} PSNR(i)$ (for each Y, U, and V)... (2)

Where t is total number of frames in video and PSNR (i) is the PSNR value for i^{th} frame.

The structural similarity (SSIM) index is a similarity measuring full reference metric between two images, means the measurement of image quality based on a reference initial uncompressed or distortion-free image. It is an improved version of traditional methods like PSNR and MSE, generally which is inconsistent with human eye perception.

$$SSIM(x,y) = \frac{(2\mu_x\mu_y + c_1)(2\sigma_{xy} + c_2)}{(\mu_x^2 + \mu_y^2 + c_1)(\sigma_x^2 + \sigma_y^2 + c_2)} \quad \text{…(3)}$$

Where
μ_x the average of x μ_y the average of y;
σ_x the variance of x and σ_y the variance of y;
σ_{xy} the covariance of x and y;
$c_1 = (k_1L)^2$, $c_2 = (k_2L)^2$
c_1 and c_2 are two variables to stabilize the division with weak denominator;
L the dynamic range of the pixel-values and $k_1 = 0.01$, $k_2 = 0.03$ by default. Equation (3) is applicable only on luma. Its value ranges between -1 and 1, where 1 is only reachable in the case of two identical sets of data. It is calculated on window sizes of 8×8.

Table 1: Performance of MPEG-4 for various Data Rate

Data Rate (Mbps)	PSNR(dB)	PSNR(dB)	SSIM	SSIM
	Base Profile	CABAC Enabled	Base Profile	CABAC Enabled
0	32.2	32.6	0.88	0.88
0.1	35.3	37.6	0.93	0.932
0.4	41.3	42.4	0.96	0.963
0.7	44.5	45.6	0.972	0.972
1	45.9	46.5	0.974	0.974
1.1	46.4	47.4	0.974	0.9755
1.4	47.9	48.5	0.976	0.9764
1.7	49	49.7	0.977	0.978
2.1	49.7	50.2	0.979	0.9798
2.2	50.6	50.9	0.98	0.982
2.7	51.8	52.4	0.981	0.984

Sequence title : Salesman
Resolution : 176× 144
Number of frames : 100

Fig. 3. Snapshot of "SA

CONCLUSION

The performance of H.264 codec with CABAC is the improvement in video quality with the use of CABAC is of the order of 0.3-0.9 db.With Cabac enabled profile SSIM improved upto 0 to 0.003.

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