Efficient Horizontal Mode Intra Frame Prediction algorithm for H.264 Advanced Video Codec

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***Abstract*: As the present communication technologies like digital television and internet video streaming are widely in routine, video compression has become an important component of broadcast and entertainment media. In this research work the core modules of the video codec has been modified and implemented. The implementation of efficient horizontal mode intra frame prediction algorithm is carried out using MATLAB and is capable of bringing about compression of video sequences as per user specification and processes picture of size 512*512 pixels, encoding at a real time frame rate of 25 fps. The compression achieved by the implementation is over 38 and the reconstructed picture quality is better than 48dB.**

***Index Terms*: Intra prediction, CAVLC, CAVLD, inverse quantization, inverse integer transform, compression, PSNR, H.264/AVC.**

I. INTRODUCTION

To improve the performance of the existing applications and to enable the applicability of video compression to real-time applications, a new international standard for video compression is developed.H.264/AVC is the latest in a series of standards published by the ITU and ISO. It describes and defines a method of coding video that can give better performance than any of the preceding standards [1]. H.264 makes it possible to compress video into a smaller space, which means that a compressed video clip takes up less transmission bandwidth and/or less storage space compared to older codec [2]. A combination of market expansion, technology advances and increased user expectation is driving demand or better, higher quality digital video. There are three profiles in H.264 (MPEG-4 Part 10/AVC for Advanced Video Coding) namely; Baseline Profile, Main Profile, Extended Profile. The Baseline profile was designed to minimize complexity and provide high robustness and flexibility for use over a broad range of network environments and conditions; the Main profile was designed with an emphasis on compression coding efficiency capability; and the Extended profile was designed to combine the robustness of the Baseline profile with a higher degree of coding efficiency and greater network robustness and to add enhanced modes useful for special "trick uses" for such applications as flexible video streaming [1-2].

This paper provides emerging studies on the new coding features of theH.264 standard. The structure of this paper is as follows: In section II the simplified basic building block of an AVC codec is described. Section III presents efficient horizontal mode of intra frame prediction algorithm. Section IV presents detailed CAVLC and CAVLD algorithm. Implementation of the proposed work is described in section V. Results and discussions are presented in section VI and conclusion is presented in the last section.

II. SIMPLIFIED BLOCK DIAGRAM OF H.264 ADVANCED VIDEO CODEC

The simplified block diagram in figure 2.1 represents advanced video codec. An input frames extracted from video are processed in units of a macro block. A macro block consists of 16x16 pixels. Each macro block is encoded in horizontal intra prediction mode [8-10] and for each block in the macro block; a prediction P (4x4 Block Samples)is formed based on the previous block samples.

The prediction P is subtracted from the current block to produce a residual (difference) block that is transformed using a block transform and quantized to give a set of quantized and scaled transform coefficients which are reordered and entropy encoded. The entropy-encoded coefficients together with other information required to decode each block within the macro block form the compressed bit stream.

The extra information required to decode each block are typically prediction mode, quantization parameter, bit stream length [11-13] etc. At the decoder side the exact reverse process of encoding is takes place i.e., the quantized coefficients are rescaled, inverse quantized and inverse transformed to produce a difference block [3-6]. The prediction block P is added to the difference block to get the reconstructed block.

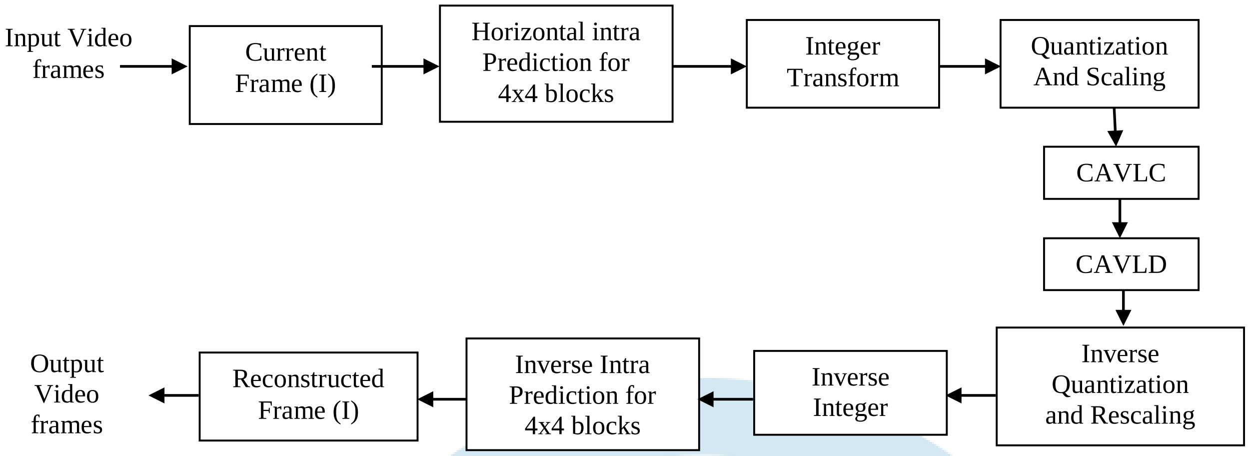


Fig 2.1: Intra frame Advanced Video Codec

III. Modified Horizontal Mode of Intra Prediction Algorithm

The horizontal mode of intraprediction is done in order to exploit the spatial redundancy within a frame as pixels close to each other tend to have similar values. Each pixel is predicted based on the values of its neighboring pixels that are available. The figure 3.1 represents modified horizontal mode of intra prediction process. In this proposed method, instead of processing the pixel value, only the difference between the actual values of the pixel and its predicted value known as the residual pixel is processed.

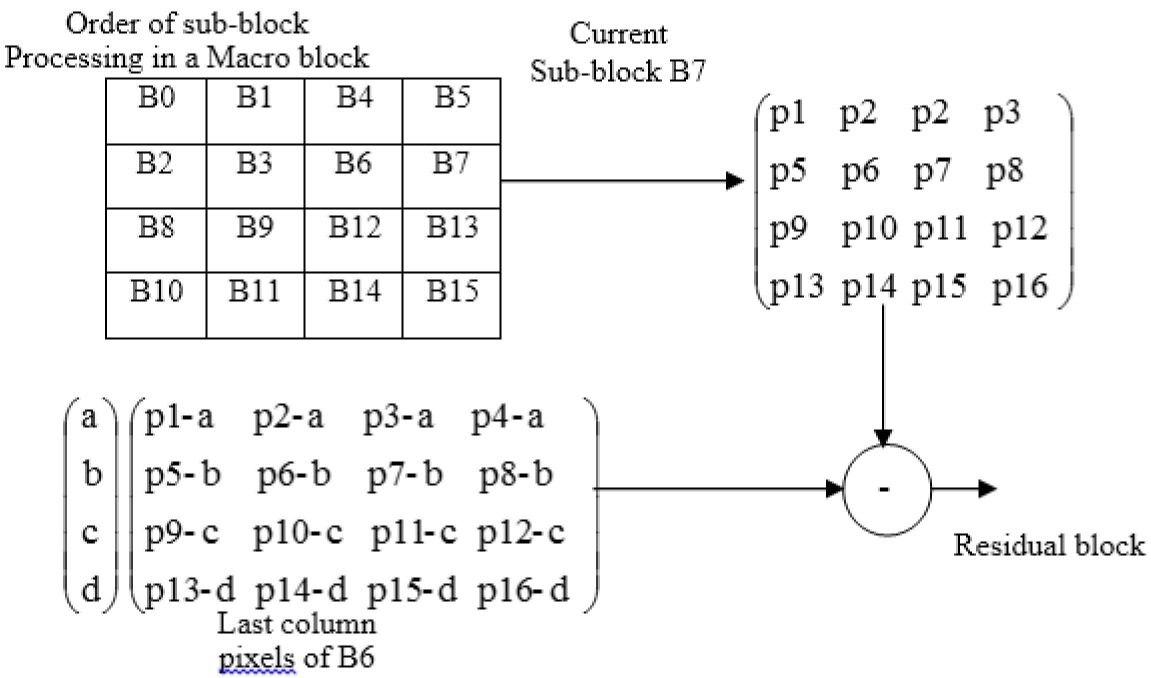


Fig 3.1: Modified horizontal mode of intra prediction

As shown in the figure 3.1 macro block consists of sub blocks (B0 to B15), consider B7 is current sub block to be processed (p1 to p16) and B6 is already processed sub block. The last column original pixels of B6 is used as a predicted pixel values for the next sub block to get a residual block, which is transformed, quantized and encoded in the preceding steps.

IV. ALGORITHM FOR PROCESSING CONTEXT ADAPTIVE VARIABLE LENGTHCODER AND DECODER

CAVLC is a form of entropy coding in H.264/MEPG-4/AVC video encoding [2]. It is an inherently lossless compression technique. It is used to encode residual, zig- zag order, blocks of transformed and quantized coefficients. CAVLC is supported in all H.264 profiles.

Consider the following quantized 4x4 sub block as an example,

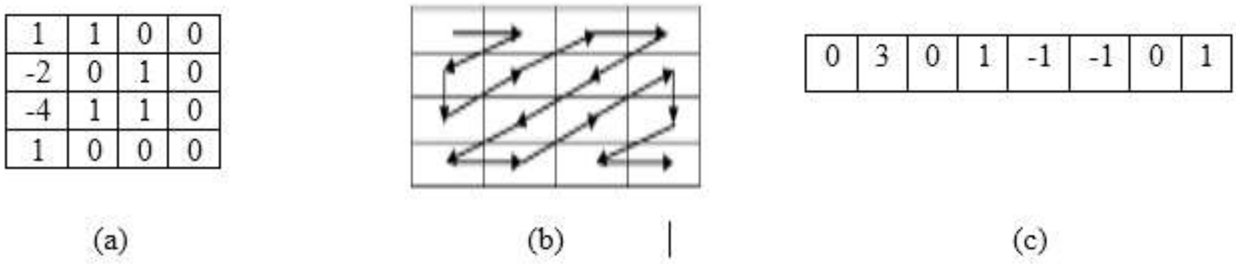


Fig 4.1: (a) Quantized Coefficients. (b) Zig-Zag Scan order. (c) Zig-Zagscan of 4x4 block
Coefficients: 1, 1, -2, -4, 0, 0, 0, 1, 1, 1, 0, 1, 0, 0, 0, 0
Nonzero Coeffs: 1, 1, -2, -4, 1, 1, 1, 1

1. Encode the number of coefficients and trailing ones.

- TotalNonZero_Coeff = 8
- Total Zeros = 4
- Trailing ones = 3
- Let nC_p = 5

(T1 3, numcoeff 8)(5-bits) = 13 <01101>(vlc 2 is selected)

2. Encode the sign of each trailing ones.

Reading from last non zero coefficient – the continuous 1s are represented in binary i.e., +1 is represented as 0 and -1 is represented as 1. Here there are three trailing ones. So there are three bits.
Reading from last, +1, +1, +1 are represented as 0, 0, 0. (3 bits) – 0<000>

3. Level encoding

For any level, there will be <Prefix>, <Suffix>

- <Prefix will have <Zeros 1>
- <Suffix> will have sign bit as LSB, the remaining bits will be derived from the non zero coefficient. Number of bits of suffix is called suffix length.

Iterations	Non zero coefficient (x)	Prefix	Suffix	Level code	Next Suffix Length
1	1	<><1>	-	<1>	1
2	-4	<000><1>	<1>	<00011>	2
3	-2	<><1>	<1><1>	<111>	2
4	1	<><1>	<0><0>	<100>	2
5	1	<><1>	<0><0>	<100>	-

4. Total zero's encoding

No. of zeros embedded in non-zero coefficients = 4
No. of non-zero coefficients = 8
Total zeros (2 bits) = 3 <11>

5. Run before (Ref. Table 5)

There are 4 zeros left and there is (1) one zero run before 1, (2 bits) – 2 <10>
There are 3 zeros left and there is (0) no zero run before 1, (2 bits) – 3 <11>
There are 3 zeros left and there is (0) no zero run before 1, (2 bits) – 3 <11>
There are 3 zeros left and there are (3) three zeros run before 1, (2 bits) – 0 <00>
Total bits (Residual) = 33
Transmitted bitstream is <01101><000><1><00011><111><100><100><11><10><11><11><00>

The CAVLD is exactly reverse process of CAVLC. Input to the CAVLD is a bitstream and length of corresponding sub block used to code in the CAVLC. There are five steps to perform decoding [14].

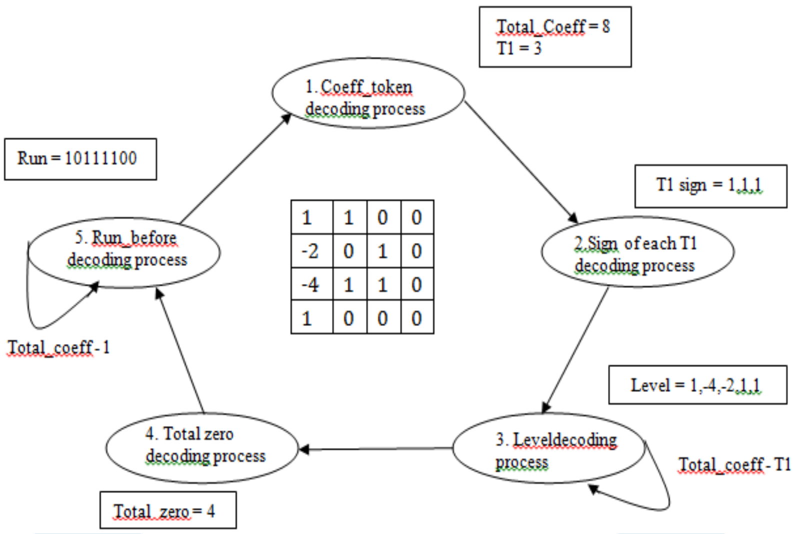


Fig 4.2: Decoding flow example of CAVLC

V. IMPLEMENTATION

Implementation of the proposed work is carried out using MATLAB. The input to this system is raw avi video file and is obtained from total video convertor which converts compressed video file to uncompressed raw video file. The video is then decomposed into frames. In the long process of H.264 video processing the very first job is to convert the video into its separate frames. For test purpose we have recorded a video of resolution 1024x768. There are a total of 130 frames, captured at a rate of 25 fps (frames per second). Hence the time of video sequence is 5.2 seconds in length. The total size of the video is 300MB. A MATLAB program is written, which reads the video file, extracts information, stores the video as movie structure and separates each frame as a separate image file. Further modified intra prediction, integer transform, CAVLC is performed on each 4x4 block of the frame. In the same way reverse process is done in order to reconstruct the original image and finally the video file. The compression ratio (CR) and peak signal to noise ratio (PSNR) achieved for both with and without horizontal mode intra prediction. Where compression is defined by

$$\text{Compression Ratio} = \frac{\text{Compressed bits}}{\text{Total number of bits}} \quad \text{---} \quad (1)$$

The quality of the reconstructed image is assessed by peak signal to noise ratio (PSNR) value defined as follows:

$$PSNR = 10\log_{10}\{255^2 * M * N / \sum\sum (i_0 - ir)\} DB \quad \text{---} \quad (2)$$

Where i_o is the original pixel intensity and i_r is the corresponding reconstructed pixel intensity.

VI. RESULTS & DISCUSSIONS

The proposed design is implemented using MATLAB in order to estimate the compression ratio and quality of the reconstructed image. The results obtained for different values of quantization parameter step sizes and corresponding quantization parameter values as specified in the table [1].

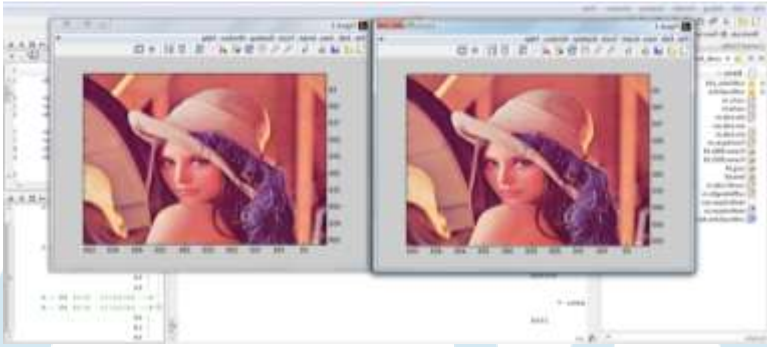
Table 1: Quality of the reconstructed video and compression achieved

QP	Q_{Step}	Compression Ratio	PSNR
0	0.625	8.18	48.14dB
3	0.875	8.76	39.87dB
9	1.75	11.65	37.76dB
18	5	23.28	36.29dB

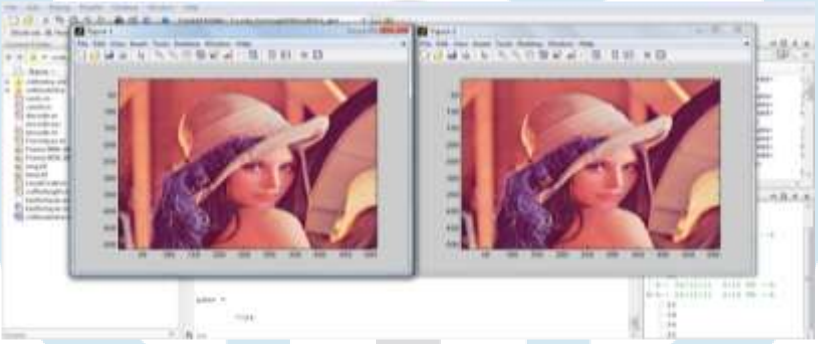
Further results are also obtained for Lena image under two scenarios as shown in the fig. (6.1 & 6.2). In the first case efficient inrtaprediction method is applied on 512x512 Lena image for different values of quantization parameter as shown in fig. and in the second case the same procedure is followed for conventional horizontal intra prediction method [3]. The table [2] depicts the comparative results obtained for the two cases.

Table 2: Comparative results obtained from modified horizontal intra prediction and

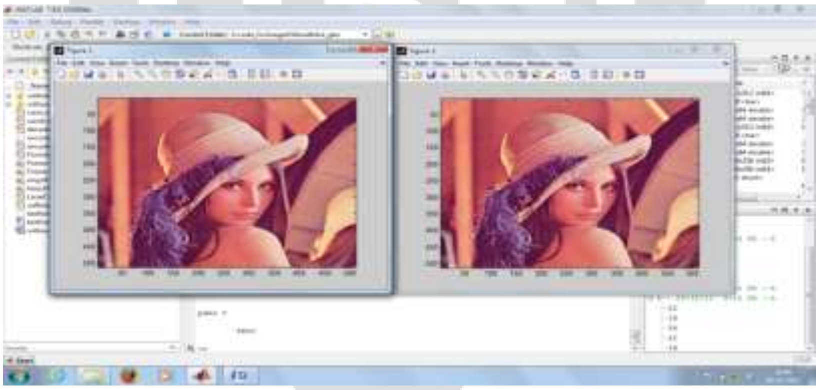
Prediction Method	QP	Compression Ratio	PSNR
Modified Horizontal Intra-frame Prediction	34	12.04	32.46
	22	7.34	36.38
	16	5.32	38.51
Horizontal Intra-frame Prediction	34	6.58	34.63
	22	4.85	38.88
	16	3.98	39.82



(a)

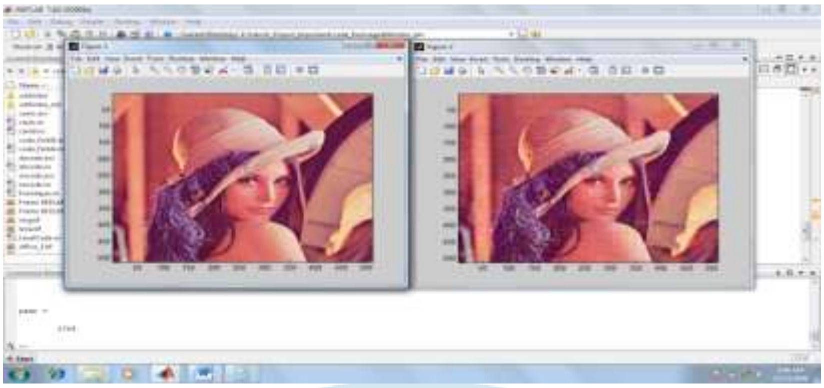


(b)

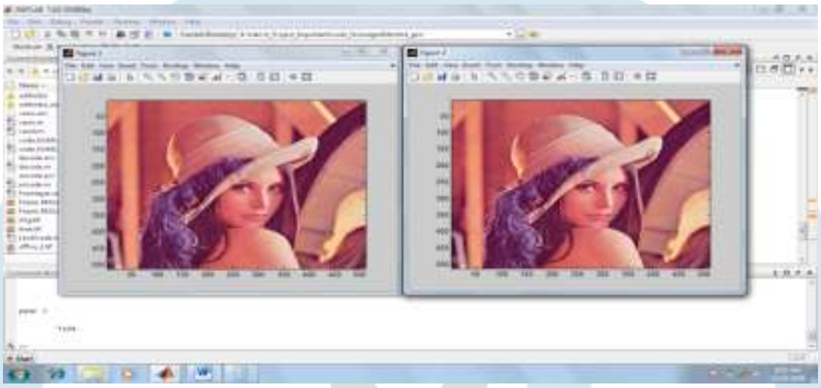


(c)

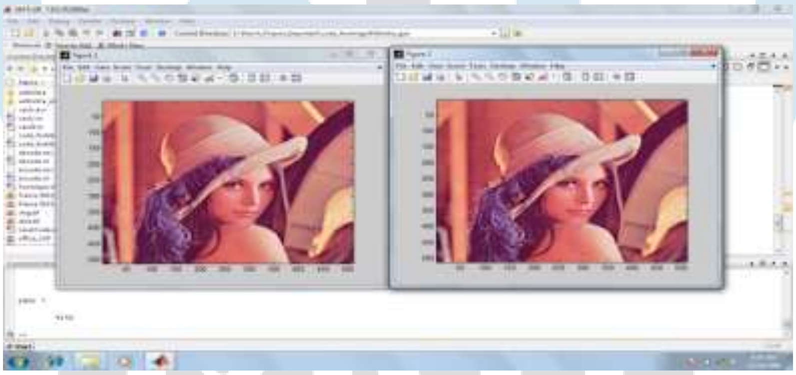
Fig 6.1: System output with conventional horizontal intra prediction algorithm for various values of QP. (a) QP = 34. (b) QP = 22. (c) QP = 16



(a)



(b)



(c)

Fig. 6.2: System output with modified horizontal intra prediction algorithm for various values of QP.
(a) QP = 34. (b) QP = 22. (c) QP = 16

VII. CONCLUSION

The design of H.264 intra frame video encoder and decoder was presented. The complete video codec was also realized using MATLAB. The results show that the reconstructed picture quality is indistinguishable from the original in spite of achieving high compression. The compression can be changed according to the user’s choice. The end user may tradeoff between compression and quality.

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