Intra Frame Coding for Advanced Video Coding Standard to Control PSNR and Bitrate using Gaussian Pulse

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Abstract- This paper proposes Intra frame coding for Advanced Video Coding Standard to control PSNR, bit rate and achieve high compression ratio using Gaussian pulse. Gaussian pulse, which improves the reconstructed image ie removes ringing, blocking artifacts and improves functionality of quantization. The Gaussian pulse operation smoothens the signal. Each Gaussian pulse multiplication scales the information content of the signal in a reversible way. The resulting signal would turn abstract. The proposed algorithm intra frame coding implemented using matlab. In the proposed algorithm Gaussian pulse applied before quantization block. The simulation results are presented using Matlab. The PSNR , compressed ratio and bit rate achived for Intra frames ie mother daughter frames, was presented for different quantization parameters with Gaussian scaling factor. The proposed algorithm gives better PSNR, compression ratio and low bit rate. The simulation results are obtained for yuv video sequences in CIF and QCIF format for different quantization parameters with Gaussian scaling factor. The simulation results are listed in table and represented rate distortion curve, compression ratio vs quantization parameter, and bit rate vs quantization parameter. The simulation results shows that the proposed algorithm achieve controlled reconstructed picture quality (PSNR), higher compression ratio and reduced bit rate.

Keywords: AVC, Macroblock, Gaussian pulse, PSNR, CAVLC, DCmode, QCIF

I. INTRODUCTION

The video compression play an important role in multi media systems.In order to reduce storage requirement video compression is very much needed.H.264/AVC is the latest video coding standard jointly developed by Joint video team in 2003,which is organized by two international standards bodies ie the Internatonal Telecommunication Union-Telecommunications sector (ITU-T) video coding experts group and International Organization for Standardization/ International Electro-technical Comission (ISO/IEC) moving picture experts group.This standard consists of various adavanced features Intra prediction unit, integer transform, variable block mation estimation, entropy encoding ,deblocking filter and coding tools.due to these features this standard achieves greater compression without sacrificing on video quality. Intra frame encoded by integer transform, Gaussian pulse, quantization and context adaptive variable length coding to get compression ratio and bit rate. In reverse process, reconstruct the picture to measure PSNR.

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Intra prediction unit is the first unit of H.264 standard. H.264 standard support intra prediction for diffent size ie 16x16 macro block as whole or 4x4 sub blocks.there are seventeen prediction modes for a macroblock, nine prediction modes for 16 4x4 luma sub macroblocks, four modes for a 16x16 luma macro block and four modes for two each two chorma 8x8 blocks. All possible combinations of intra prediction modes are used it lead to increase computational complexity of H.264 encoder and it is difficult to use for real time applications.All the modes are not relavant to all the applications. The existing video compression standards such as MPEG-2, MPEG-4 support adaptive changes in the compression ratio and bitrate. The quantisation steps are varied by the appropriate choice of quantisation matrix coefficients. The matrix may be chosen from a set of matrices defined by the standard or user can drive altogether a new matrix in which case the coefficients need to be transmitted along with the bit stream. A coarse step reduces the bitrate and increases compression at the cost of drastic reduction in the PSNR of the reproduced image. so that proposed algorithm is implemented to avoid image getting bad hit and to achive controlled PSNR and bit rate with high compression ratio in a contolled way.

II. METHODOLOGY

A raw recorded yuv video sequence in QCIF and CIF format is used as an input file. Recorded yuv video sequence is then decomposed into only intra frames (mother-daughter_cif, foreman_cif, Akiyo news_ cif, etc). Each intra frame is processed in terms of 4x4 sub block of macro block. Each intra frame processing is done in order to get high video quality and high compression ratio and low bit rate as compared to previous video coding standards. Each intra frame processing includes frame conversion i.e. RGB to Ycbcr format down sampling i.e. (4:4:4 to 4:2:0). 4x4 sub blocks from 16x16 macro block of intra frame, residual, integer transformation, Gaussian pulse quantization and entropy encoding at forward path. The intra frame is reconstructed by doing inverse process at the reconstruction path.

In the proposed algorithm each 4x4 sub macro block of intra frame is transformed into frequency domain samples using integer transformer, these samples are multiplied with Gaussian pulse, which smoothens the signal in reversible way to avoids picture image getting bad hit, blocking artifacts and improves functionality of quantize block, quantized coefficients are encoded using context adaptive variable length coding to obtain compressed bit to get compression ratio and bit rate. In the reverse process quantized coefficients are inverse quantized and inverse transformed to reconstruct the frame, after measuring PSNR of frame.

III. BLOCK DIAGRAM

The block diagram of H.264 encoder for selection of Intra prediction modes is shown in fig.1. The h.264 encoder block consists of integer transform, Gaussian pulse, quantization context adaptive variable length coding, inverse quantization, invese transformation, intra prediction unit and deblocking filter.

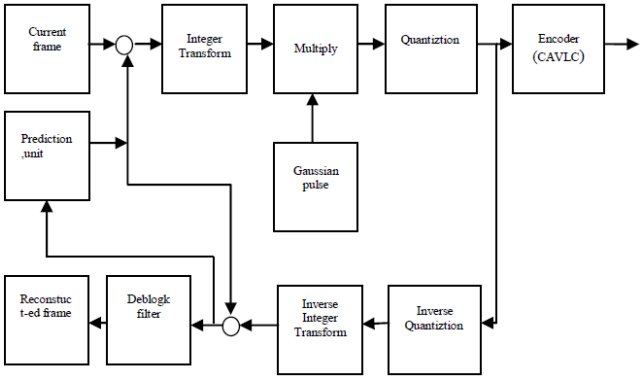

Fig.1 Block diagram of H.264 encoder

The block diagram of H.264/AVC encoder includes two dataflow paths, a forward path and a reconstruction path. An input frame is given for encoding. Every frame is processed in terms of a Macroblock (MB) of size 16x16 pixels. Each macroblock is further sub divided into 4x4 sub macroblock. Each 4x4 sub macroblock is encoded in intra prediction modes. A prediction macroblock P is formed based on a reconstructed block. In intra mode, P is formed from samples in the current block is based on previously reconstructed block. The prediction P is subtracted from the current macroblock to produce a residual or difference macroblock. This is transformed using integer transform, transformed coeffients are multiplied with Gaussian pulse and quantized using quantization block to give quantized transform coefficients. These coefficients are reordered and entropy encoded using context adaptive variable length coding (CAVLC) and the compressed bit stream is transmitted over a band-limited serial transmission channel In the reconstruction path the quantized macroblock coefficients are decoded to reconstruct a frame for encoding of other macroblocks. The quantized coefficients are inverse quantized and inverse transformed to produce a difference macroblock. The prediction macroblock P is added to difference maroblock to create a reconstructed macroblock after a de-blocking filter, which improves the quality of the reconstructed frame[1-2].

IV. INTRA FRAME CODING

The H.264/AVC intra prediction unit achieves higher compression ratio and image quality compared with preivious standard(JPEG2000).The H.264 support different block sizes, it supports 4x4 and 16x16 block sizes for base line, main and extended profiles and 8x8 block size for high profile. There are nine prediction modes for 4x4 blocks, four for 16x16 blocks and and two for 8x8 blocks. All the prediction pixels are calculated based on the the reconstructed pixels of previously encoded neighbouring blocks. The prediction of 4x4 blocks is predicted based on the previously reconstructed pixels labelled (**A-M)** shown in Fig.2 the pixels (**A-M)** are reconstructed previously and consider as reference pixels for current block. The pixels labeled (**a-m)** are prediction pixels.

M	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**
I	a	b	c	d				
J	e	f	g	h				
K	i	j	k	l				
L	m	n	o	p				

Fig. 2. labeling of 4x4 prediction samples

Each 4x4 sub macroblock is predicted using eight directional prediction modes and one DC mode.The directional prediction modes are vertical, horizontal, diagonal down left, horizontal down, diagonal down right, vertical left, horizontal up, vertical right.For directional modes the predicted samples are formed from a weighted average of the perdiction samples **A-M**.For DC mode the predicted samples are formed by mean of samples A-D and I-L.The encoder select prediction mode for each 4x4 sub macroblock.The selection of best prediction mode is obtained by minimizing the residual encoded block and its prediction[3-5]. The fig.3 shows the intra prediction modes.

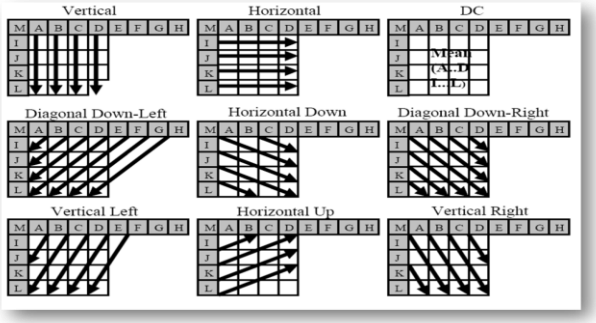

Fig.3. 4x4 intra prediction modes

The equations of 4x4 sub macroblock for few prediction modes are:
Mode 0:Vertical

a=e=i=m=A
b=f=j=n=B
c=g=k=o=C
d=h=l=p=D

Mode 1:Horizontal
a=b=c=d=I
e=f=g=h=J
i=j=k=l=K,
m=n=o=p=L
Mode 2: DC
Mean of A-D and I-L,
for horizontal prediction sum of (A-D) and vertical prediction sum of (I-L).
Mode 3:Diagonal Down Left
a=(A+2B+C+2)>>2
b=e=(B+2C+D+2)>>2
c=f=i=(C+2D+E+2)>>2
d=g=j=m=(D+2E+F+2)>>2
h=k=n=(E+2F+G+2)>>2
i=o=(F+2G+H+2)>>2
p=(G+3H+2)>>2.

V. STEPS OF IMPLEMENTATION

The following steps are to required for intra frame coding in AVC using Gaussian pulse.

- A raw recorded YUV video sequence in qcif and cif format is used as an input file.
- This input file is decomposed into only Intra frames (I-frame) (1-30).
- Each frame is processed in terms of macro block; macro block consists of 16x16 pixels.
- A 16x16 macro block is further divided into a 4x4 sub macro block.
- A first 4x4 sub block is processed directly without using previously reconstructed block followed by integer transform, Gaussian pulse, quantization, entropy encoding at encoder and reverse process at decoder.
- Reconstruct a 4x4 sub block using inverse process (at reconstruction path)
- Obtain residual block by subtracting next 4x4 sub block with previously reconstructed sub block.
- Residual of 4x4 sub block is integer transformed, Gaussian pulse, quantized and entropy encoded at encoder and reverse process at decoder.
- Apply DC prediction mode to each 4x4 sub block.
- Finally measure PSNR, compression ratio and bit rate for different intra frames with different QP and Gaussian scaling factor.

VI. IMPLEMENTAION

The proposed work is carried out using Matlab. The input is yuv sequences CIF format video file. For test purpose mother-daughter frame of resolution 352x288 and also other frames (foreman, Akiyo news, etc) also taken, A Matlab program is written, which reads the yuv video file, extracts only Intra frames. The next process involves reading a true RGB colour frame and convert into **ycbcr** format down sampling (4:4:4 to 4:2:0) to reduce bits of intra frame.ycbcr intra frame is divided into 4x4sub block is processed directly by following usual procedure of forward path of H.264 encoder and reconstruct the processed block which serves as reference to the next sub block using basic reverse process in reconstruction path of H.264 encoder. Obtain the residual block by subtracting reconstructed bock with current block. Residual coefficients are integer transformed, transformed coefficients (i.e. frequency samples) are multiplied by Gaussian pulse, these coefficients are, quantized and encoded using context adaptive variable length coder (CAVLC) to get compressed bit. At H.264 encoder in the reconstruction path, perform reverse processes to get reconstruct image and finally measure quality picture (PSNR) for DC mode.
Measure PSNR, Compression ratio and bit rate for different scaling parameters of Gaussian and quantization parameters.

VII. RESULTS AND DISCUSSION

The proposed work Intra frame coding is done using Gaussian pulse. The results obtained for the yuv video sequences in CIF and QCIF frames and different quantization parameters and Gaussian scaling factor for DC prediction mode (mode 2).

Table-I

		Qp	PSNR (db)	Compression ratio (%)	Bit rate (Mbps)
Gaussian scaling factor V= 0.2	Mode-2	0	39.08	69.91	17.46
		10	39.11	79.81	12.14
		15	39.13	84.27	9.13
		20	39.16	88.49	6.68
		25	39.21	91.90	4.70
		30	39.33	94.51	3.19
		35	39.32	96.44	2.07
		40	39.14	97.61	1.38
		51	36.64	98.71	0.75

Table-II

		Qp	PSNR (db)	Compression ratio (%)	Bit rate (Mbps)
Gaussian scaling factor V= 0.1	Mode-2	0	38.98	69.01	17.98
		10	39.02	78.81	12.29
		15	39.03	83.06	9.83
		20	39.07	87.72	7.12
		25	39.13	91.42	4.97
		30	39.27	94.26	3.33
		35	39.31	96.29	2.15
		40	39.23	97.50	1.45
		51	37.52	98.69	0.76

The results obtained for the test yuv sequences in CIF and QCIF format,such as mother daughter, foreman CIF frames and akiyo news QCIF frame for quantization parameter (0-51) with different gaussian scaling factor(0.1,0.2 and 1).The table I, II and III gives PSNR, compression ratio and bit rate reduction of intra frame coding of mother daughter yuv cif frame for mode 2 with different quantization parameters and Gaussian scaling factors 0.1, 0.2, 1. The rate distortion curve for different quantization parameters with scaling factor V=0.1 is shown in fig. 4.

Table-III

		Qp	PSNR (db)	Compression ratio (%)	Bit rate (Mbps)
Gaussian scaling factor V= 1	Mode-2	0	33.17	82.15	10.35
		10	33.26	90.38	5.58
		15	33.05	93.43	3.81
		20	33.03	95.52	2.60
		25	32.83	96.99	1.75
		30	33.09	97.95	1.19
		35	32.25	98.53	0.85
		40	32.20	98.81	0.69
		51	31.41	98.95	0.61

It indicates that for different quantization, controlled PSNR and reduced bit rate achieved.The graph of compression ratio for different quantization parameters with scaling factor V=0.1 is shown in fig.5. It indicates that for different quantization, high compression ratio achieved. The bit rate for different quantization parameters with scaling factor V=0.1 is shown in fig.6. It indicates that for different quantization, reduced bit rate achieved. The simulation results fig.7-18 indicates original mother daughter frame, reconstructed frame and reconstructed frame with de-blocking filter for different

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quantization paremeter with Gaussian scaling factor V=0.1. fig.19-23 indicates original akiyo news frame, reconstructed frame and reconstructed frame with de-blocking filter for different quantization paremeter with Gaussian scaling factor V=1. fig.24-23 indicates original foremen frame, reconstructed frame and reconstructed frame with de-blocking filter for different quantization paremeter with Gaussian scaling factor V=0.2.

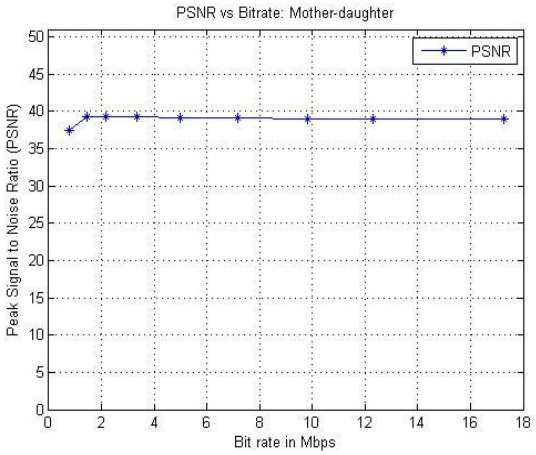

Fig.4. rate distortion curve for V=0.1

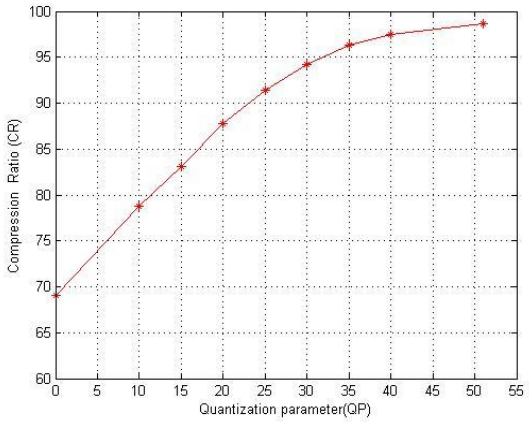

Fig.5.Compression vs Quantization V=0.1

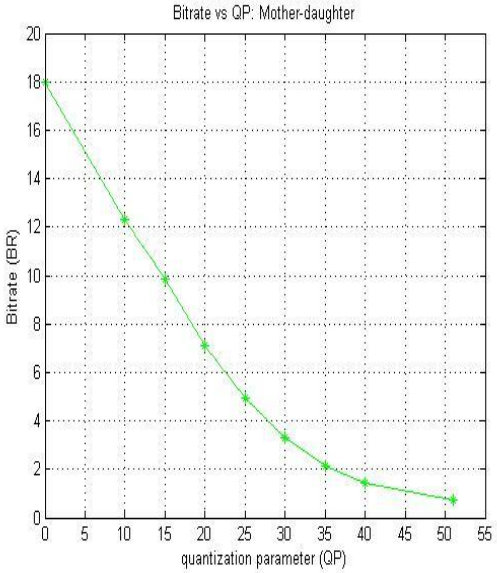

Fig.6.Bitrate vs Quantization V=0.1

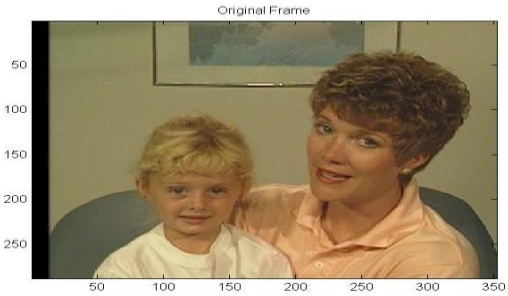

Fig.7. original frame

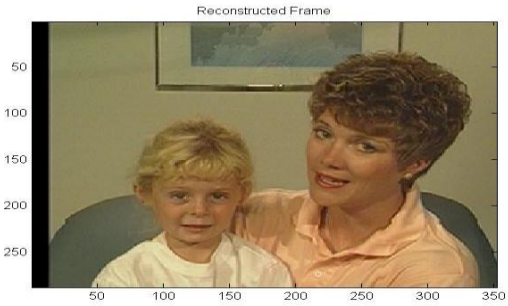

Fig.8.Reconstucted frame (QP=0, V=0.1)

Fig.9.Reconstucted frame (QP=5, V=0.1)

Fig10..Reconstucted frame (QP=10, V=0.1)

Fig.11.Reconstucted frame (QP=15, V=0.1)

Fig.12.Reconstucted frame (QP=20, V=0.1)

Fig.13.Reconstucted frame (QP=25, V=0.1)

Fig.14.Reconstucted frame (QP=30, V=0.1)

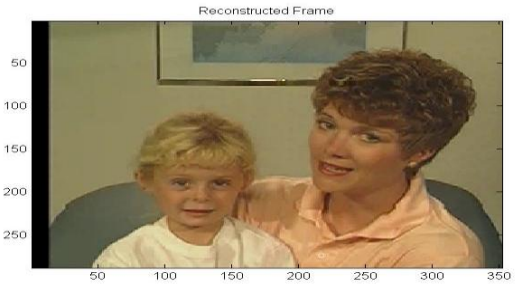

Fig.15.Reconstucted frame (QP=35, V=0.1)

Fig.16.Reconstucted frame (QP=40, V=0.1)

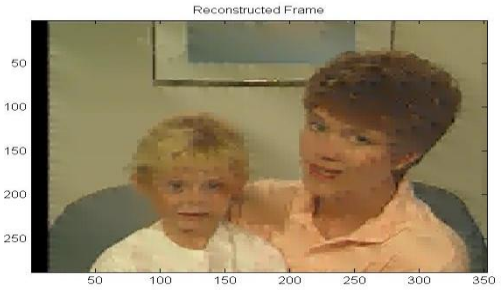

Fig.17.Reconstucted frame (QP=51, V=0.1)

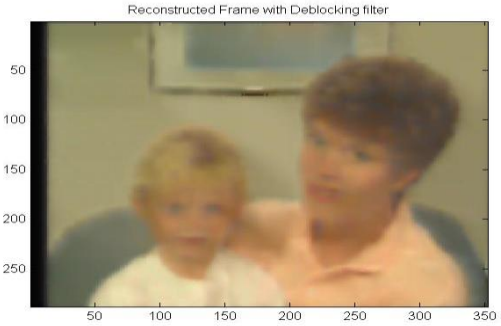

Fig.18.Reconstucted frame with de-filter (QP=51, V=0.1)

Fig.19.Original frame

Fig.20.Reconstucted frame (QP=0, V=1)

Fig.21.Reconstucted frame (QP=35, V=1)

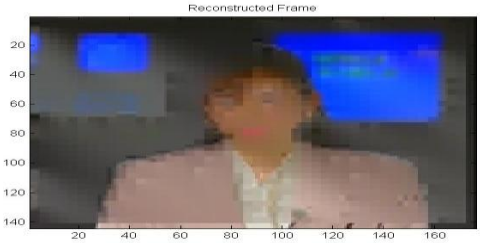

Fig.22.Reconstucted frame (QP=51, V=1)

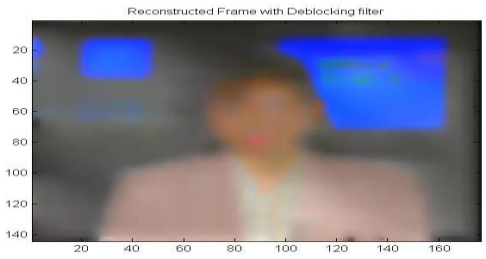

Fig.23.Reconstucted frame with de-filter (QP=51, V=1)

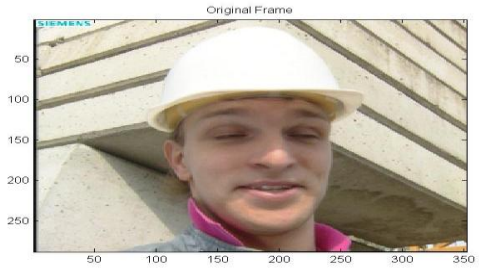

Fig.24. original frame

Fig.25.Reconstucted frame (QP=0, V=0.2)

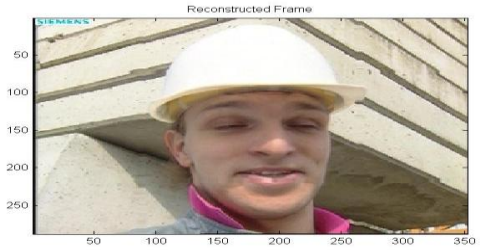

Fig.26.Reconstucted frame (QP=10, V=0.2)

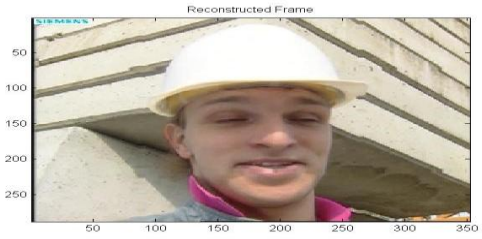

Fig.27.Reconstucted frame (QP=30, V=0.2)

Fig.28.Reconstucted frame (QP=40, V=0.2)

Fig.29.Reconstucted frame (QP=51, V=0.2)

VIII. CONCLUSIONS

The proposed work is intra frame coding using Gaussian pulse in a controlled manner for mode 2 ie DC mode of intra prediction unit. It is observe that using Gaussian pulse can achieved controlled PSNR, higher compression ratio and reduced bit rate.The simulated results are presented in table (I-III) and rate distortion curve, compression and bit rate curve for scaling factor, mode-2. The results shows that the controlled reconstructed picture quality (PSNR), higher compression ratio and reduced bit rate achieved.

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