SELECTION OF INTRA PREDICTION MODES FOR INTRA FRAME CODING IN ADVANCED VIDEO CODING STANDARD

Manjanaik.N[1], Manjunath.R[2]

[1]*Electronics and Communication Engineering, Jain University, Bangalore, India.*
[2]*Senior Domain Specialist, Philips Company, Bangalore, India.*
manjubdt2009@gmail.com, manju_r_99@yahoo.com

Abstract

This paper proposes selection of Intra prediction modes for Intra frame coding in Advanced Video Coding Standard using Matlab. The proposed algorithm selects prediction modes for intra frame coding. There are nine prediction modes are there to predict the intra frame in AVC using Intra prediction,but all the prediction modes are not required for all the applications. Intra prediction is the first process of advanced video coding standard. It predicts a macro block by referring to its previous macro blocks to reduce spatial redundancy,appling all the prediction modes to predict intra frame it leads to more computational complexity is increased at the encoder of AVC. In the proposed algoriyhm, applied all the prediction modes(0-8) for prediction of intra frame but only few modes such as mode0, mode1, mode2,mode4,mode6 gives good PSNR, high comprssion ratio and low bit rate. Out of these modes mode2 gives good PSNR, compression ratio and redced bit rate, mode5, mode7 and mode8 gives lower PSNR, low compression ratio and increased bitrate compared to mode0,mode1, mode2, mode4 and mode6. The simulation results are presented using Matlab. The PSNR , compressed ratio and bit rate achived for different quantization parameters of mother daughter frames , foreman frames was presented.

Keywords*: AVC, PSNR, CAVLC, Macroblock, Prediction modes.*

----------***----------

1. INTRODUCTION

Compression is the basic process of reduceing the size of data in order to save storge space and transmission band width.compression consist of removing redundancies (spatial,spectra and temporal) and encoding the true information in the form of appropriate to suite for applications. There are two compression techniques ie. Lossless and lossy techniques. In lossless the reconstured image after comprssion is identical to original image, this method achieve maximum compression ratio.To compress data ,it is important to recognize redundancies in data in the form of coding redundancy, inter- pixel redundancy, and psycho-visual redundancy. Data redundancies occur when unnecessary data is used to represent source information. compression is achived when one or more of these types of redundancies are reduced.In lossy the reconstructed image is not identical to the original image ie there is loss in information.lossy method is capble of achiving a high comprssion compare to lossless method. Image compression/video coding is impotant in indusrial imaging, commercial and academic applications. Image /video coding plays a important role in multimedia. H.264/AVC is the latest video coding standard jointly developed by Joint video team which is organized by two international standards bodies ie the Internatonal Telecommunication Union-Telecommunications sector (ITU-T) and International Organization for Standardization/ International Electro-technical Comission (ISO/IEC). 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 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, so that proposed algorithm is implemented for nine prediction mode.out of these mode few modes gives good PSNR, high compression ratio and low bit rate. These modes can use for suitable multi media applications.

2. METHODOLOGY

A raw recorded video in yuv format is used as an input file. The video is then decomposed into frames(I-frame). Each Intra frame is processed in terms of 4x4 sub macro block. For each Intra frame processing is done in order to get good video

quality, high compression ratio and low bitrate as compared to previous video coding compression 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 macro block segmentation, all prediction modes (vertical, horizontal,DC, diagonal down left, horizontal down, diagonal down right, vertical left, horizontal up, vertical right etc) integer transformation, quantization, scaling and entropy encoding(cavlc). The video is reconstructed by inverse quantization, inverse transformation and deblocking filter.

3. 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, quantization context adaptive variable length coding, inverse quantization, invese transformation, intra prediction unit and deblocking filter.

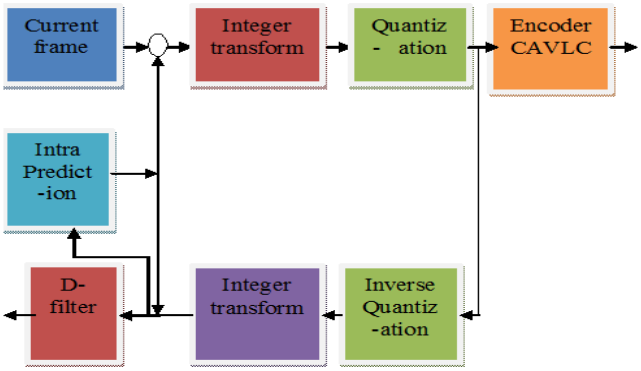

Fig.1 Block diagram of H.264 encoder

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 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].

4. INTRA PREDICTION

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.

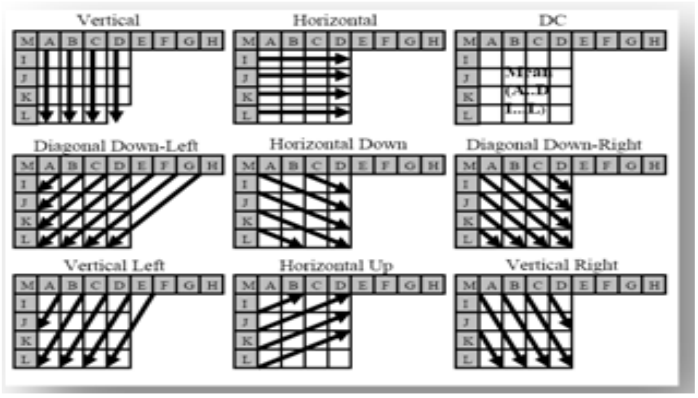

Fig.3. 4x4 intra prediction modes

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

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

Horizontal

a=b=c=d=I
e=f=g=h=J
i=j=k=l=K,
m=n=o=p=L

DC

Mean of A-D and I-L,
for horizontal prediction sum of (A-D) and vertical prediction sum of (I-L).

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.

5. STEPS OF IMPLEMENTATION

The following steps are to required to selection of intra prediction modes for intra frame coding in AVC.

- A recorded video in YUV CIF format as input file
- This file is decomposed into Intra frames (1-30)
- Each I-frame is divided into 16x16 macroblocks
- Eac h 16x16 macroblock further sub divided into 4x4 sub macroblocks
- A first 4x4 sub block is processed directly without using previously reconstructed block followed by integer transform, quantization, entropy encoding (cavlc) at encoder and reverse process at reconstruction path.
- Reconstruct a 4x4 subblock 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, quantized and entropy encoded at encoder and reverse process at reconstuction path.
- Finally measure PSNR, Compression ratio and Bit rate of intra frames with different QP for all prediction modes

6. 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, news, etc) also taken, A Matlab program is written, which reads the yuv video file, extracts 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. Apply all the prediction modes to each sub block followed by, quantization, context adaptive variable length coder (CAVLC) to get compressed bit. At H.264 encoder in the reconstruction path, perfom reverse process to get reconstruct image and finally measure quality picture (PSNR).

7. RESULTS AND DISCUSSION

The proposed method, selection of intra prediction modes and best prediction mode for intra frame is done using Matlab. The test sequences are coded with only intra frames with frame rate 25 frames per second.The results obtained for the test yuv sequences in CIF format, five forman cif frames for quantization parameter 30 and ten mother-daughter cif frames for quantization parameter 35. Other quantization parametes[10, 25, 40, 45,51] also chosen (not shown in table).

Table-1

PSNR, Compression ratio, Bit-rate, of foreman cif frames (1-5) with QP=30						
	Modes	Frame1	Frame2	Frame3	Frame4	Frame5
PSNR db	0	31.75	31.7723	31.7593	31.7743	31.755
	1	31.743	31.7171	31.6864	31.6939	31.67

	2	31.9123	31.9029	31.878	31.891	31.8734
	3	31.3911	31.3794	31.3674	31.3834	31.3826
	4	31.3611	31.3585	31.3511	31.359	31.3526
	5	28.6738	28.6752	28.6804	28.6671	28.6521
	6	30.5477	30.5331	30.5119	30.5188	30.5123
	7	27.2161	27.2159	27.2144	27.2127	27.1954
	8	26.6998	26.6965	26.6952	26.692	26.6837
Compression Ratio (%)	0	75.5339	75.5365	75.5508	75.6185	75.4362
	1	75.319	75.3607	75.319	75.2826	75.2435
	2	76.8424	76.8776	76.7617	76.9245	76.7943
	3	68.6198	68.7096	68.8906	68.7891	68.6549
	4	66.7331	66.9635	66.9193	66.9245	66.9596
	5	42.625	42.6003	42.6523	42.6185	42.6042
	6	67.6641	67.6849	67.6589	67.8789	67.6875
	7	59.1706	59.2604	59.2995	59.2396	59.1602
	8	53.1146	53.1276	53.181	53.1758	53.1393
Bit rate	0	3.5839	3.5835	3.5814	3.5715	3.5982
	1	3.6154	3.6093	3.6154	3.6207	3.6264
	2	3.3922	3.3870	3.4040	3.3802	3.9928
	3	4.5967	4.5835	4.5570	4.5719	4.5915
	4	4.8730	4.8393	4.8458	4.8450	4.8399
	5	8.4054	8.4081	8.4005	8.4054	8.4075
	6	4.7367	4.7336	4.7374	4.7052	4.7332
	7	5.9808	5.9677	5.9619	5.9707	5.9824
	8	6.8679	6.8660	6.8582	6.8590	6.8643

The table 1 shows comparison of nine intra prediction modes for formen cif frames 4x4 sub macroblocks with QP=30 and table 2 shows that comparison of nine prediction modes for mother-daughter cif frames 4x4 sub macroblocks with QP=35. The various figs (4-22) are simulation results (i.e. original frame, reconstructed frames and reconstructed frames with deblocking filter) of mother-daughter cif frames, foreman cif frames, news cif frames for nine intra prediction modes (0-8) and quantization parameters-30, 35. Quantization parameter 30 for foreman cif frames, news cif frames. Quantization parameter 30 mother-daughter cif frames.

Table 2

PSNR ,Compression ratio, Bit-rate of mother-daughter_cif frames(1-10) with QP=35											
	Modes	Frame1	Frame2	Frame3	Frame4	Frame5	Frame6	Frame7	Frame8	Frame9	Frame10
PSNR in db	0	33.14123	33.1166	33.10555	33.13742	33.14686	33.13439	33.11761	33.1143	33.1006	33.10746
	1	33.08717	33.05939	33.07195	33.099	33.09906	33.10453	33.09241	33.10064	33.07036	33.06456
	2	33.20455	33.19078	33.19016	33.21944	33.22558	33.2023	33.18459	33.19254	33.17163	33.17553
	3	32.67051	32.64043	32.66463	32.68794	32.68958	32.69664	32.65912	32.65468	32.66058	32.66091
	4	32.69006	32.67825	32.6745	32.70011	32.70622	32.70534	32.67992	32.69209	32.66437	32.67972
	5	30.34563	30.33966	30.34171	30.35221	30.36275	30.35223	30.33657	30.34927	30.34033	30.35441
	6	32.69446	32.69688	32.69399	32.72496	32.74467	32.72919	32.70603	32.69553	32.70138	32.70141
	7	28.53597	28.53009	28.54107	28.53057	28.53239	28.54504	28.54817	28.54717	28.54423	28.54054
	8	27.78601	27.78477	27.789	27.7796	27.78141	27.7853	27.78161	27.78453	27.78259	27.79232
Compression Ratio (%)	0	86.23307	86.14453	86.21875	86.23307	86.27865	86.21094	86.17188	86.11719	86.14063	86.13021
	1	86.25651	86.22526	86.22656	86.21484	86.38021	86.3112	86.25	86.23177	86.23307	86.24089
	2	86.71875	86.67057	86.66276	86.72005	86.75781	86.71875	86.6875	86.58984	86.66016	86.63281
	3	81.03906	81.07161	81.17057	81.10026	81.14193	81.16927	81.11458	81.1224	81.11589	81.17318
	4	80.38411	80.31771	80.35026	80.47266	80.46484	80.4401	80.41536	80.46615	80.44531	80.27604
	5	44.80078	44.75781	44.73568	44.76432	44.71224	44.70573	44.80339	44.78125	44.75911	44.7474
	6	79.38932	79.3151	79.28906	79.39844	79.45833	79.46484	79.40104	79.28516	79.28646	79.43099
	7	64.83724	64.82422	64.84766	64.91276	64.86979	64.86979	64.86719	64.83854	64.86589	64.82031
	8	57.54427	57.5013	57.48438	57.50391	57.55339	57.55859	57.56641	57.53125	57.5625	57.58464
Bit rate (Mbps)	0	2.01664	2.02961	2.018738	2.01664	2.009964	2.019882	2.025604	2.033615	2.030182	2.031708
	1	2.013206	2.017784	2.017593	2.01931	1.995087	2.005196	2.01416	2.01683	2.01664	2.015495
	2	1.945496	1.952553	1.953697	1.945305	1.939774	1.945496	1.950073	1.964378	1.954079	1.958084
	3	2.777481	2.772713	2.758217	2.768517	2.762413	2.758408	2.766418	2.765274	2.766228	2.757835
	4	2.873421	2.883148	2.87838	2.860451	2.861595	2.865219	2.868843	2.861404	2.864456	2.889252
	5	8.085823	8.092117	8.09536	8.091164	8.098793	8.099747	8.085442	8.088684	8.091927	8.093643
	6	3.019142	3.030014	3.033829	3.017807	3.009033	3.00808	3.017426	3.034401	3.03421	3.013039
	7	5.150795	5.152702	5.149269	5.139732	5.146027	5.146027	5.146408	5.150604	5.146599	5.153275
	8	6.219101	6.225395	6.227875	6.225014	6.217766	6.217003	6.215858	6.221008	6.216431	6.213188

Mode 0

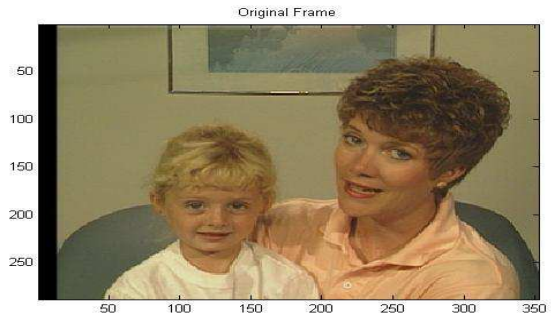

Fig.4. Original frame

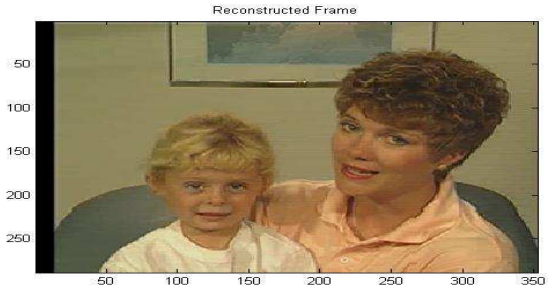

Fig.5. Reconstructed frame

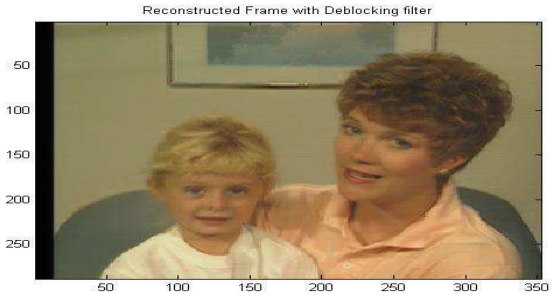

Fig.6. Reconstructed frame with Deblocking-filter

Mode 1

Fig.7. Reconstructed frame

Mode 2

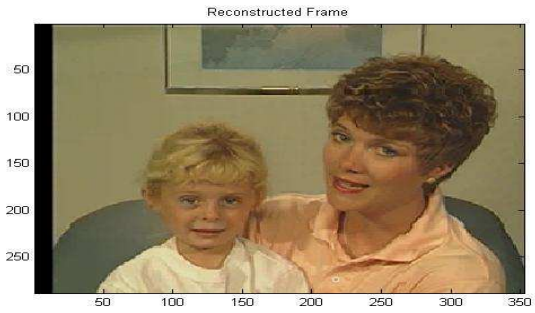

Fig.8. Reconstructed frame

Mode 3

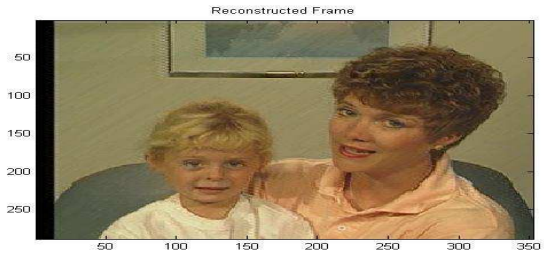

Fig.9. Reconstructed frame

Mode 4

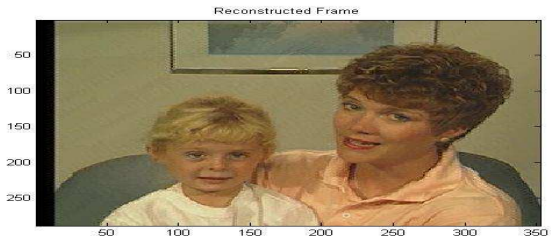

Fig 10. Reconstructed frame

Mode 5

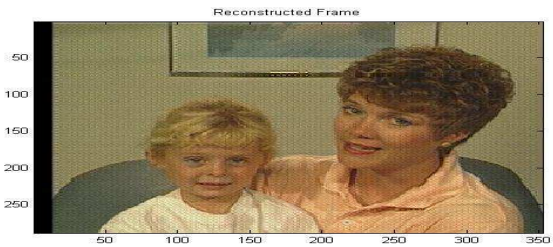

Fig.11. Reconstructed frame

Mode 6

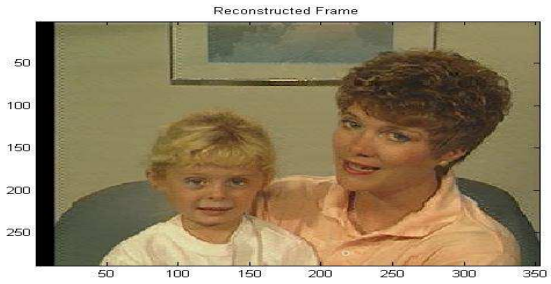

Fig.12 Reconstructed frame

Mode 7

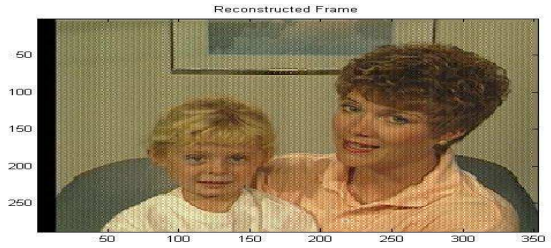

Fig.13. Reconstructed frame

Mode 8

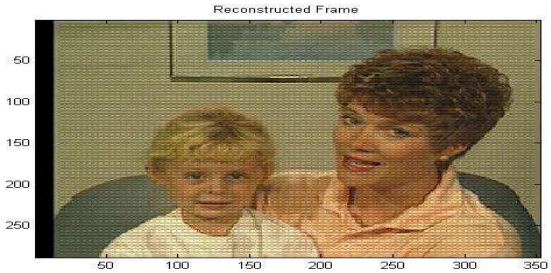

Fig.14. Reconstructed frame

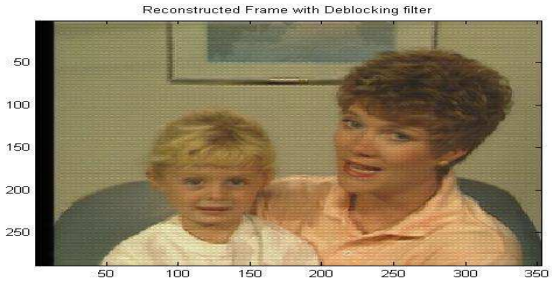

Fig.15. Reconstructed frame with Deblocking-filter

Mode 0

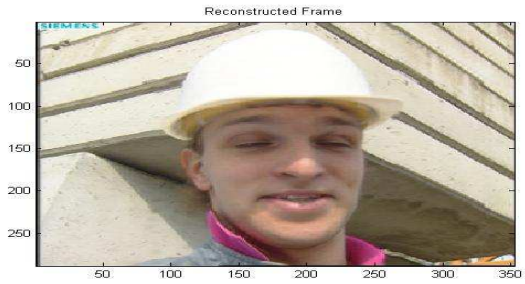

Fig.16. Reconstructed frame

Mode 1

Fig.17. Reconstructed frame

Mode 2

Fig.18. Reconstructed frame

Mode 7

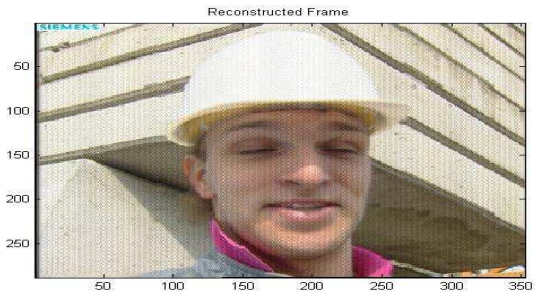

Fig.19. Reconstructed frame

Mode 8

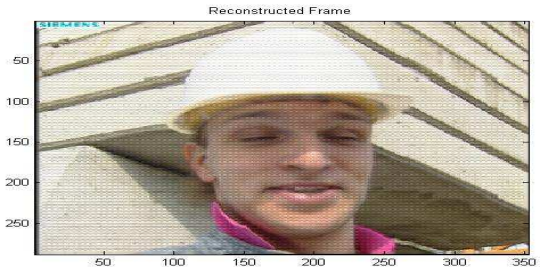

Fig.20. Reconstructed frame

Mode 0

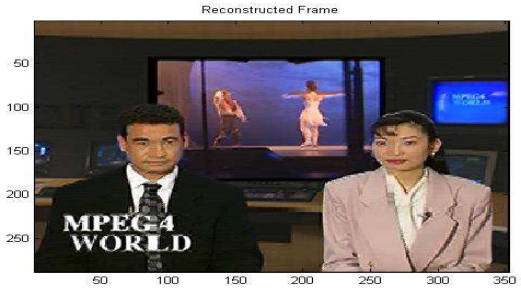

Fig.21. Reconstructed frame

Mode1

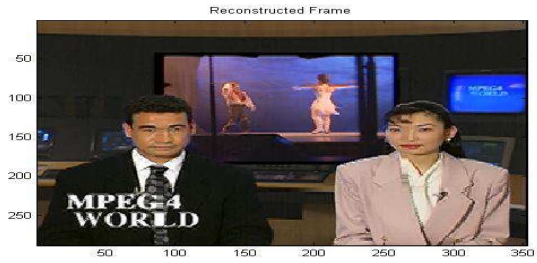

Fig.22. Reconstructed frame

Mode2

Fig.23. Reconstructed frame

Mode 7

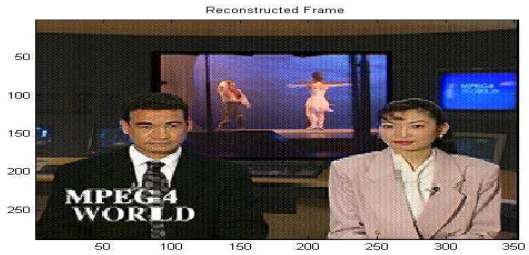

Fig.24. Reconstructed frame

Mode 8

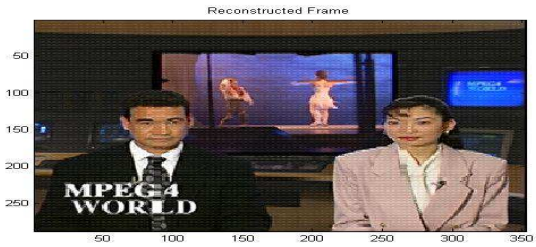

Fig.25. Reconstructed frame

CONCLUSIONS

The proposed work is selection of intra prediction modes and best prediction mode for intra frame coding in advanced video coding standard is carried out using Matlab. The results shows that the reconstructed picture quality (PSNR), compression ratio and bit rate achieved for test yuv I-frames, CIF format (mother-daughter and foreman and news) for different quantization parameters. Obtained results for all the nine intra prediction modes. The mode0, mode1, mode2, mode3, mode4 and mode6 gives good PSNR, compression ratio and low bit rate (tables I And II) compared to mode 5, mode7 and mode 8. In the proposed method The mode0, mode1, mode2, mode3, mode4 and mode6 gives good PSNR, compression ratio and low bit rate, out of these modes mode 2 gives high PSNR, compression ratio and Low Bit rate indicted yellow mark in table(I and II), which is the best prediction mode.

REFERENCES

[1]. Iain E.Richardson,*The H.264 and MPEG-4 Video Compression :Video coding for Next-generation Multimedia*, Johan Wiley& Sons, first edition 2003.

[2]. Iain E. Richarson, *The H.264 Advanced Video Compression Standard*, Johan Wiley& Sons, Second edition 2010.

[3]. Youn-Long Steve Lin, Chao-Yang Kao Hung-Chih Kuo *VLSI Design for Video Coding*, Springer-2010.

[4]. Huang Hui, Cao Tie-Yong, Zhang Xiong-wei, The Enhanced Intra Prediction Algorithm for H.264,congress on Image and signal processing 2008.
[5]. Chaminda Sampath Kannangara, Complexity Management of H.264/AVC Video Compression, the Robert Gordon University 2006.
[6]. http://www.vcodex.com