PERFORMANCE EVALUATION OF H.264/AVC FIDELITY RANGE EXTENSIONS

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Abstract
The latest video compression standard, H.264/AVC standard has introduced Fidelity Range Extensions (FRExt) as coding tools to increase the applications areas towards high definition video storage and transmission in an efficient manner. This paper describes performance analysis of Fidelity Range Extensions of this standard. The three profiles High, High10 and Baseline are compared by using reference software JM 15.1. Test video sequences of different environment at various bit rates are used to evaluate performance of FRExt. The objective and subjective simulation results show that high profiles of FRExt are more efficient in coding performance as compared to baseline H.264/AVC standard.

Keywords H.264/AVC, FRExt, Coding performance

Introduction

H.264 is the latest entry of international video coding standard as product of a combined effort by the Joint Video Team (JVT) [1]. H.264 has demonstrated improved coding efficiency, increased flexibility, reducing complexity design, enhancing error robustness to make it more efficient and more compatible with much more applications as compared to the previous standards [2-3]. However, H.264/AVC standard targeted on such applications which require low video resolutions i.e. video supporting 8 bits per sample and 4:2:0 sampling of chrominance components. Therefore extensions have been proposed in H.264/AVC known as Fidelity Range Extensions, FRExt which supports higher video resolutions [4-5]. The development committee has reported substantial gains by performing coding simulations but much research is still required for better assessment. With this idea, our research work shows comparison of latest H.264 FRExt (High and High10 profiles) and H.264 Baseline standard. Also usage of 4x4, 8x8 and adaptive transform within the High profiles has been evaluated. Section 2 depicts overview of H.264/AVC FRExt and its innovation. Section 3 illustrates performance analysis and simulation results of H.264/AVC FRExt while section 4 concludes the paper.

Overview of H.264/AVC FRExt

The main purpose of FRExt is to focus on the most demanding application areas like post processing, content contribution, studio editing and content distribution [5-6]. The FRExt of H.264/AVC was previously known as "professional" Extensions. The various profiles on H.264/AVC FRExt are shown in Figure1.

As depicted in Figure1, H.264/AVC FRExt specifies four additional profiles having interleaved qualities which are basically extended form of Main profile. Four profiles are High profile (HP) 4:2:0 8 bit/sample, High 10 profile (Hi10P) 4:2:0 up to 10 bit/sample, High 4:2:2 profile (H422P) up to 10 bit/sample, High 4:4:4 profile (H444P) up to 12 bit/sample. High 4:4:4 include support for predictive lossless coding and residual colour transforms. Each High profile supports all capabilities of its nested profile. High10, High 4:2:2 and High 4:4:4 profiles enhance the capabilities of previous profiles including more demanding applications which need higher chrominance precision, higher bit depths and higher sample precision. All new profiles support all features of main profile adding adaptive block switching between 8x8 and 4x4 transform (the main distinguishing feature from all the Non-FRExt profiles), perceptual quantization matrices and specific control of quantization parameter. Organizations which have adopted FRExt as their video compression standard are HD-DVD specification of the DVD Forum, BD-ROM Video specification of the Blue ray Disc Association, and DVB (digital video broadcast) standards for European broadcast

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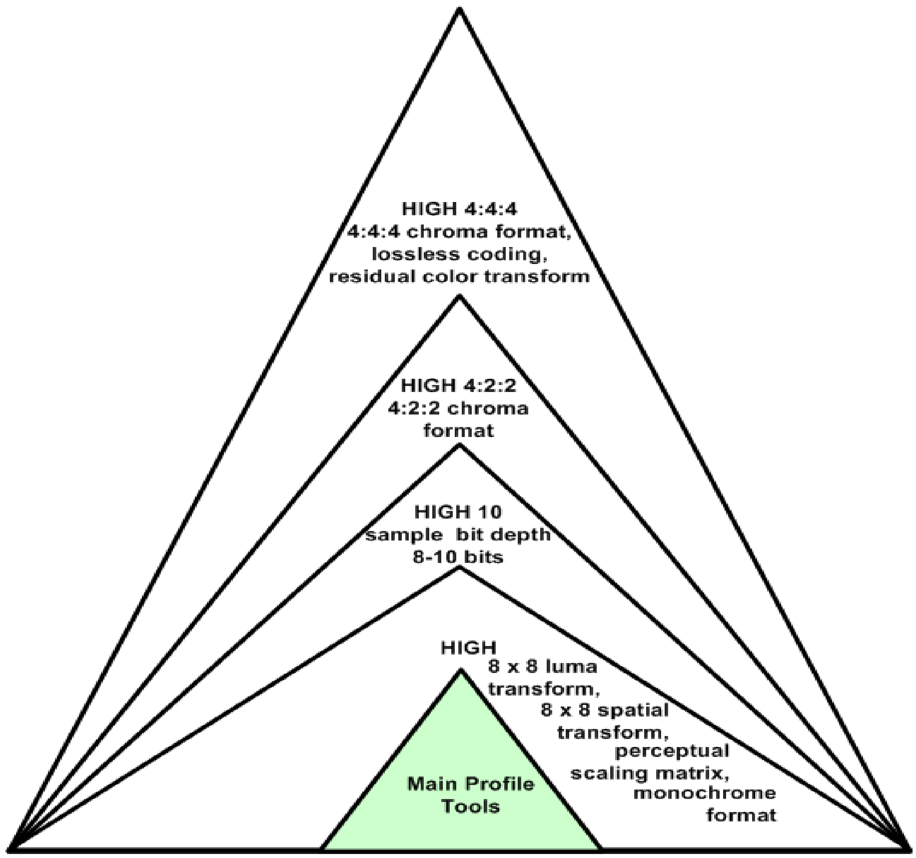

Figure 1. Interleaved high profiles of H.264/AVC FRExt

of the Blue ray Disc Association, and DVB (digital video broadcast) standards for European broadcast television. The summary of comparison of applications of H.264/AVC baseline and FRExt is shown in Table 1.

Performance Evaluation of H.264/AVC FRExt

To analyze the performance of FRExt, different input video sequences were encoded using JM FRExt 15.1 [7]. We have analyzed the performance of FRExt for mobile video applications such as video conferencing, video on internet, mobile TV, PDA's, hand held devices. CIF (Common Intermediate Format) and QCIF (Quarter Common Intermediate Format) video formats are therefore used in this analysis as these are supported by above mentioned applications. All video sequences are YUV (4:2:0) namely "Foreman", "Coastguard", "Mother Daughter", "Silent" and "Hall" [8]. The test environment is summarized in the given Table 2.

A comparison of luminance PSNR (Peak Signal to Noise Ratio) vs. bit rate was made among different sequences of high, high10 profiles of FRExt and Baseline profile of H.264/AVC. Bit rates were selected according to the standards specified internationally for each video format.

Table 1 Applications of H.264 baseline and FRExt

H.264 Baseline	▪ Video Conferencing ▪ Videophone ▪ Video-on-Demand ▪ Multimedia streaming services over ISDN, cable modem, DSL, LAN, wireless networks etc.
FRExt Profiles	▪ Content contribution ▪ Content distribution ▪ Studio editing ▪ Post processing ▪ HD-DVD specification ▪ DVB (digital video broadcast) ▪ BD-ROM (Video specification of the Blue-ray Disc Association)

Table 2 Test environment

Profile IDC	FRExt (high(100), high10(110)) , Baseline(66)
Deblocking filter	Off
Format	QCIF(176X144), CIF(352X288)
RD optimization	Enabled
LEVEL IDC	20 ,40
Q-Matrix (Scaling matrix)	Disabled
CAVLC	Enabled (Baseline)
Rate Control Enable	Enabled
CABAC	Enabled (High and High10)
Transform	4x4, adaptive, 8x8
Frames encoded	50
YUV Format	4:2:0
Frame Rate	30 frames per second

Table 3 and 4 summarizes the statistics of CIF High profile Vs. Baseline profile and QCIF High profile Vs. Baseline profile respectively. For High profile, CIF sequences were encoded at bit rates of 0.5 Mbps to 2.5Mbps while QCIF at 30Kbps to 600Kbps. High10 profile was used at bit rates of 0.2 Mbps to 6Mbps for CIF and at 20 Kbps to 600Kbps for QCIF format.

Table 3 Rate PSNR comparison between high and baseline profiles for QCIF sequences

Sequence	*Bit rate (kbps)*	*Y PSNR (dB)*						
		H.264 Base-line	*FRExt High Profiles*					
			High			*High 10*		
			4x4	*8x8*	*Adaptive*	*4x4*	*8x8*	*Adaptive*
QCIF Foreman	28	28.97	29.07	28.72	29.53	30.74	30.72	31.01
	62	32.39	33.71	33.44	33.81	33.86	33.64	34.09
	103	35.64	36.90	36.31	36.85	37.18	36.64	37.27
	129	36.82	37.99	37.41	38.08	38.27	37.84	38.44
	154	37.72	38.83	38.29	38.94	39.22	38.67	39.24
QCIF Coastguard	46	28.09	30.04	30.12	30.23	30.16	30.19	30.33
	90	29.32	32.41	32.43	32.59	32.53	32.40	32.70
	192	32.78	35.31	35.13	35.39	35.46	35.21	35.54
	280	33.62	37.31	37.08	37.33	37.48	37.30	37.59
	390	33.62	38.87	38.60	38.90	38.92	38.78	39.19
QCIF Mother Daughter	48	37.74	38.65	38.35	38.82	39.09	39.03	39.42
	92	37.91	42.97	42.68	42.79	43.80	43.36	43.98
	146	41.76	44.40	43.75	44.28	45.70	45.19	45.78
	195	43.37	45.04	44.47	44.99	46.88	46.45	47.05
	523	44.25	50.67	50.11	50.84	51.98	51.73	52.02

Table 4 Rate-PSNR comparison between high and baseline profiles for CIF Sequences

Sequence	*Bit rate (Mbps)*	*Y PSNR (dB)*						
		H.264 Baseline	*FRExt High Profiles*					
			High			*High 10*		
			4x4	*8x8*	*Adaptive*	*4x4*	*8x8*	*Adaptive*
CIF Foreman	0.5	33.80	38.59	38.13	38.64	35.16	34.87	35.25
	1.0	40.81	41.54	41.12	41.56	41.49	40.99	41.53
	1.5	42.34	42.99	42.49	43.04	43.64	43.17	43.66
	2.0	43.63	44.25	43.76	44.32	45.35	44.93	45.41
	5.0	44.55	50.50	50.04	50.58	46.64	46.29	46.88
CIF Coast-guard	0.5	28.09	31.7	34.2	31.86	35.77	36.29	36.41
	1.0	29.32	34.83	35.03	35.09	41.65	41.51	41.57
	1.5	31.45	36.90	37.03	37.11	43.92	43.93	44.01
	2.0	32.78	38.49	38.62	38.87	45.72	45.87	45.97
	5.0	33.62	46.71	46.33	47.05	52.10	52.08	52.36
CIF Mother Daughter	0.5	37.74	43.42	43.31	43.42	41.56	41.80	48.67
	1.0	37.91	45.92	45.77	45.94	49.81	47.34	47.11
	1.5	41.76	46.82	46.70	46.87	50.06	50.14	50.24
	2.0	43.37	47.99	47.86	47.98	51.73	51.80	51.91
	4.4	44.25	52.61	52.01	52.66	56.10	53.78	52.66

Subjective comparison for Mother Daughter sequence between FRExt adaptive, 8 x8, 4x4 and baseline H.264 is shown in Figure 2.

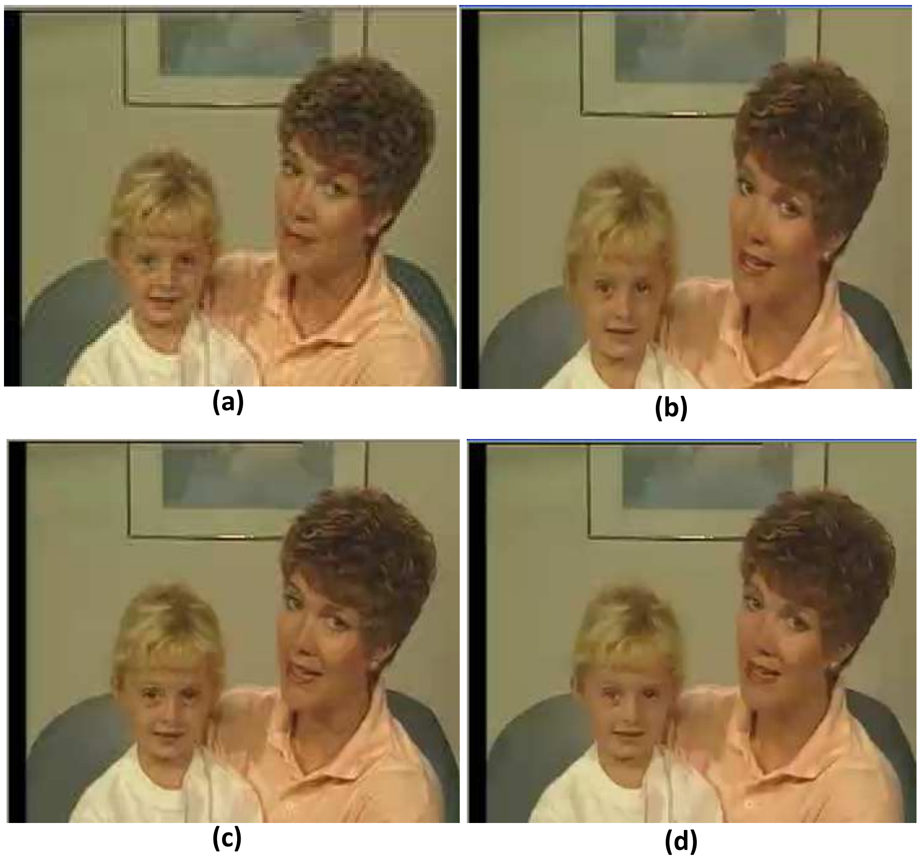

Figure 2. Frame 5 of Mother Daughter Sequence encoded at 200 Kbps
(a) FRExt Adaptive (b) FRExt 4x4 (c) FRExt 8x8 (d) H.264 Baseline

Figure 3 show comparison of PSNR at various bit rates between FRExt High10 profile and baseline H.264 for QCIF Coastguard and CIF foreman respectively.

These graphs clearly show that FRExt profiles have much better PSNR than Baseline profile and also among FRExt profiles, 4x4 and adaptive exceed in PSNR values from 8x8 transform mode.

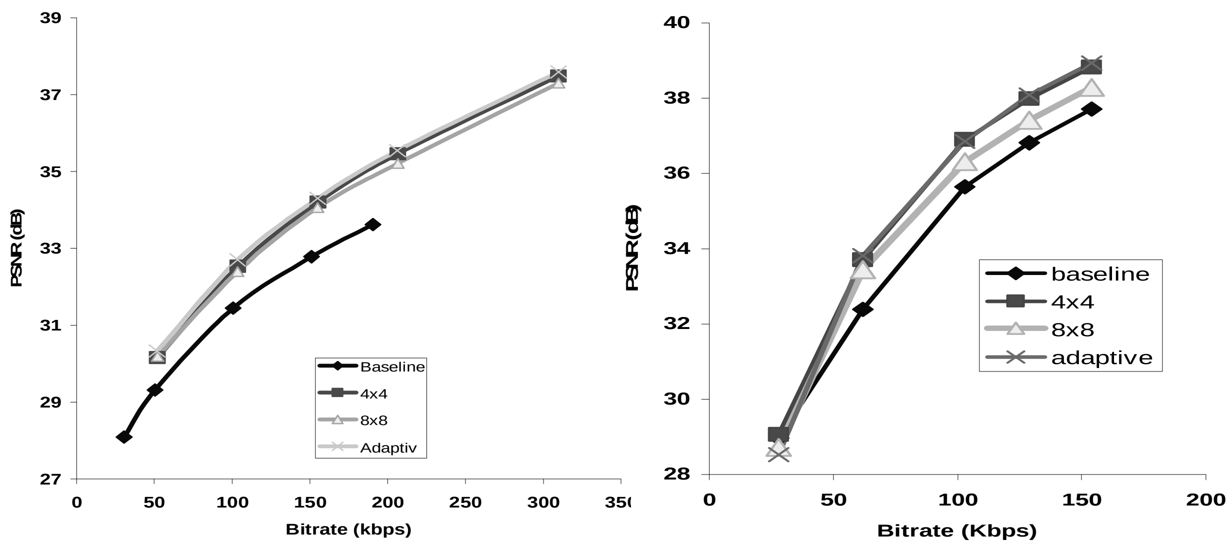

Figure 3. PSNR comparison at various bitrates (Left) QCIF Coastguard (Right) CIF Foreman

Conclusion

An in-depth performance analysis of H.264/AVC FRExt is performed. The results have shown that the FRExt profile far exceeds in efficiency and robustness than other profiles like baseline. The study also revealed that 4x4 and adaptive transform have higher coding gains than 8x8 transform. Because of these reason FRExt is becoming the preferable choice for video compression experts.

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