Rate-distortion comparison of CS-JPEG codec with JPEG, x264-intra and x265-intra

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I. Introduction

This is supplemental materials to work [1] which introduces CS-JPEG codec with intra-frame encoding and inter-frame decoding. Table I shows encoding speed comparison of CS-JPEG with MATLAB implementation of JPEG [2], x264 [3] (core:157 r2935 545de2f) and x265 [4] (version 2.3+33-0b7d54dbb71a87a0) which are fast software implementations of H.264/AVC [5] and H.265/HEVC [6] encoders, respectively. All the codecs were run without any software optimization tools, such as assembler optimization or threads. Here *ultrafast* means that x264 or x265 encoder is used in its fastest preset, while *veryslow* corresponds to the full RD optimization. One can see that in average CS-JPEG encoder is 2.2, 1.9, 26.2 and 30.5 times faster than JPEG, *x264-ultrafast*, *x264-veryslow* and *x265-ultrafast*, respectively.

TABLE I: Encoding speed in frames per second for 'Foreman', 352×288 resolution, 300 frames, on CPU 2.8 GHz

R_T, kbps	*JPEG*	*x264-intra*		*x265-intra*	*CS-JPEG*
		ultrafast	*veryslow*	*ultrafast*	
600	223	346.8	24.3	17.0	551.7
1000	221	271.3	19.1	15.6	516.8
1500	213	216.6	15.9	14.9	444.4
2000	199	176.9	13.8	14.4	380.9

Table II shows ΔPSNR [7] provided by CS-JPEG codec in comparison to the intra-codecs mentioned above. Here the positive values mean that CS-JPEG provides better performance. All the codecs, except JPEG, were run in constan bit rate mode with target bit rate from set $R_T \in \{600, 1000, 1500, 2000\}$ kbps. For JPEG we manually found the closest quality factor which provides the requred target bit rate. All the tests were performed only for (Y) luma components, while U and V components were set to 128. All the test sequences have 352×288 frame resolition, from 240 to 300 frames. More detailed rate-distortion curves can be found in Figures 1–5. One can see that in average CS-JPEG provides much faster encoding with better recovery performance than JPEG, *x264-ultrafast* and *x265-ultrafast*. Since, CS-JPEG exploits the temporal similarity between neighbor frames, i.e., higher similarity means better reconstruction. On the other hand, if the temporal similarity is low, then the traditional block-based intra codecs could provide better performance since they exploit the spatial similarity of pixels within a frame more efficiently. In order to show this effect numerically, we introduced the temporal similarity level S using the same equation as for PSNR calculation, where the mean square error is calculated between current frame and motion-compensated previous frame.

TABLE II: ΔPSNR related to different intra-codecs

Test video	S, dB	*JPEG*	*x264-intra*		*x265-intra*
			ultrafast	*veryslow*	*ultrafast*
Bridge-close	59.7	3.48	1.58	1.30	2.67
Container	48.6	5.20	2.91	2.53	4.18
Bridge-far	45.2	1.80	-0.77	-0.27	0.68
Akiyo	39.9	4.43	2.85	0.53	3.40
Mother-daughter	37.2	2.36	1.07	-0.88	1.02
Students	37.2	4.74	3.23	2.25	4.06
Hall	36.2	5.77	3.17	1.41	4.31
Waterfall	36.1	1.68	1.08	0.56	1.28
Silent	32.2	3.37	2.46	1.35	2.65
Deadline	32.0	6.37	4.14	2.68	5.24
News	31.5	6.19	4.27	2.34	5.58
Pamphlet	31.4	6.54	4.60	2.59	5.11
Bowing	30.6	5.15	2.79	0.71	3.64
Paris	30.3	5.04	3.29	1.89	4.06
Sign_irene	29.5	-0.50	-2.61	-3.80	-1.60
Tempete	26.8	0.55	0.01	-1.04	0.01
Harbour	26.5	1.96	1.27	0.06	0.96
Carphone	26.4	1.31	-0.49	-2.41	-0.19
Crew	25.5	-1.59	-2.45	-3.63	-2.06
Foreman	24.5	0.61	-0.20	-1.97	-0.28
Coastguard	24.4	0.48	-0.52	-1.26	-0.53
City	24.2	-0.08	-0.87	-1.35	-0.36
Ice	22.9	-0.49	-2.23	-4.05	-0.15
Soccer	21.1	-1.17	-2.22	-2.79	-1.66
Football	20.0	-2.31	-3.35	-4.35	-2.66
Mobile	19.5	-0.55	-1.24	-1.88	-0.44
Flower	17.7	-0.71	-1.86	-2.28	-1.15
Average	31.0	**2.21**	**0.74**	**-0.44**	**1.40**

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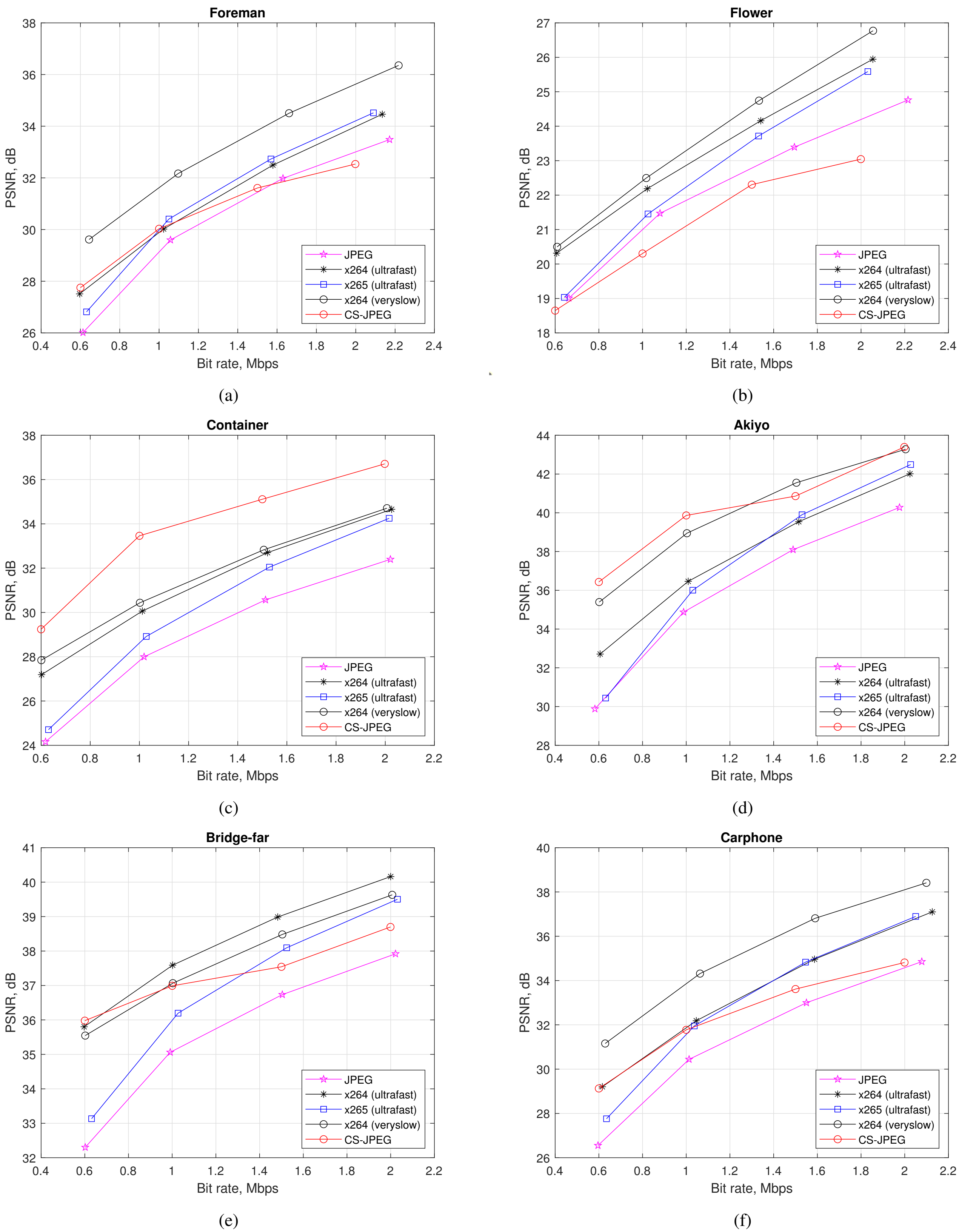
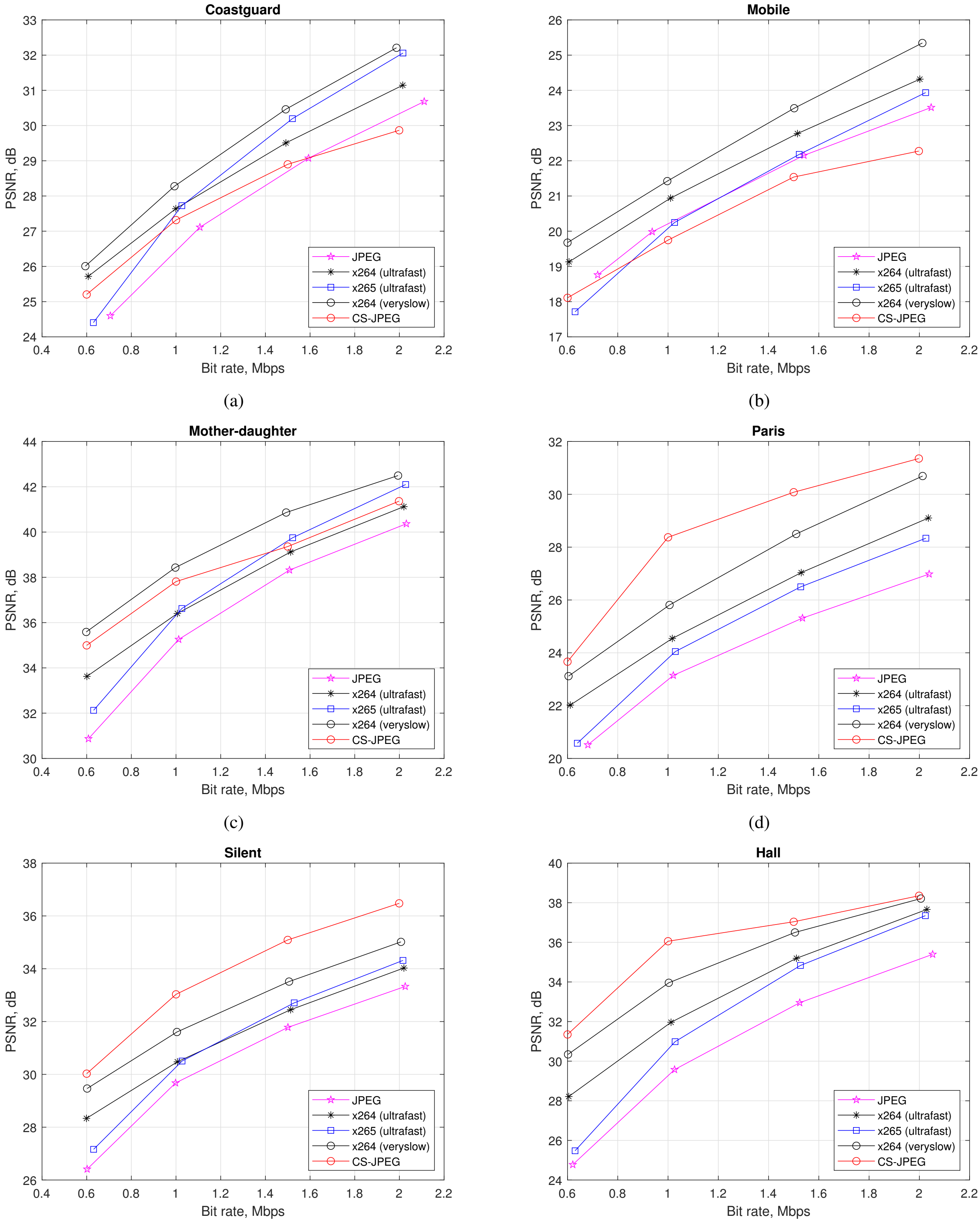


Fig. 1: Rate-distortion comparison of video codecs with intra-frame encoding



(e) (f)

Fig. 2: Rate-distortion comparison of video codecs with intra-frame encoding

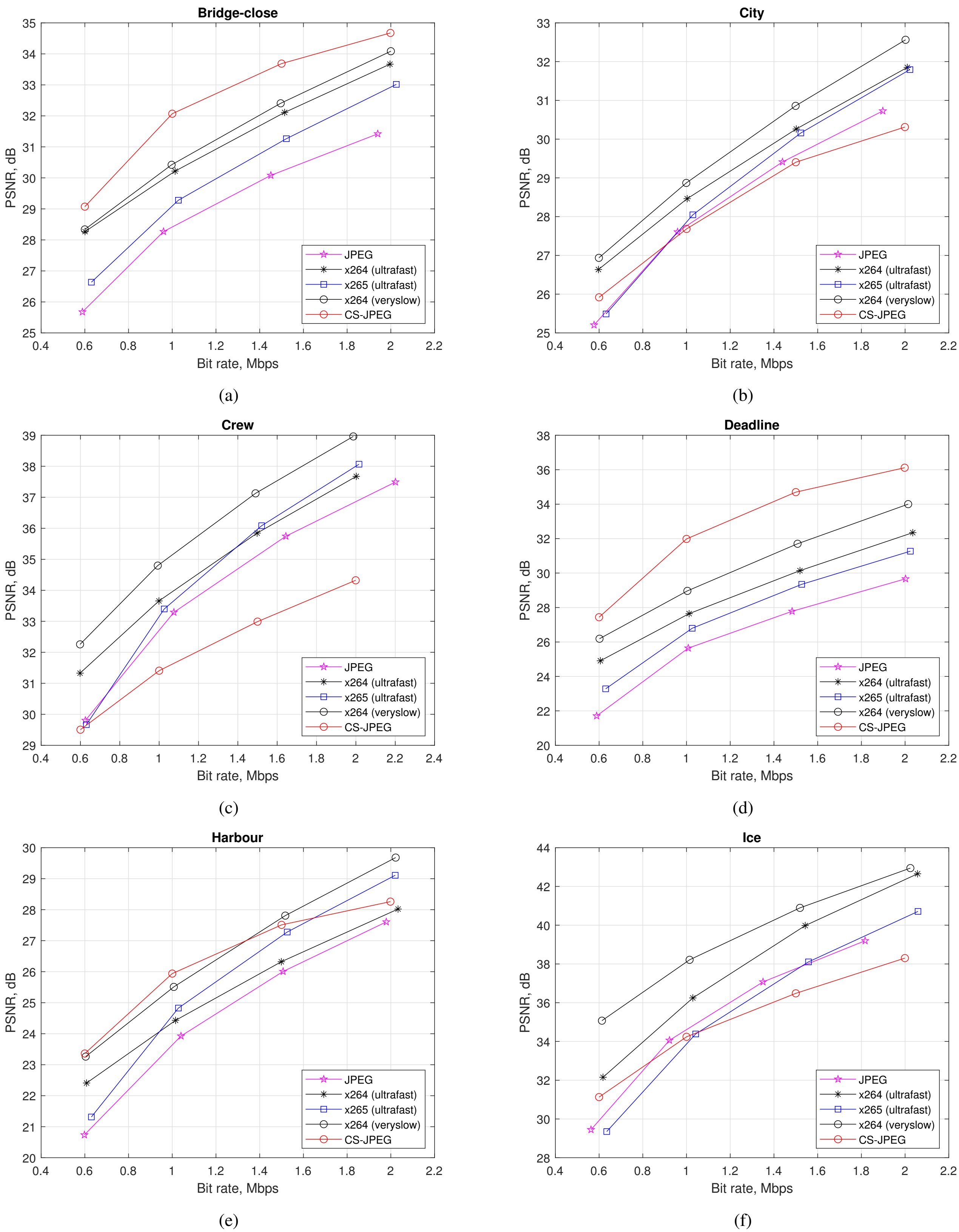


Fig. 3: Rate-distortion comparison of video codecs with intra-frame encoding

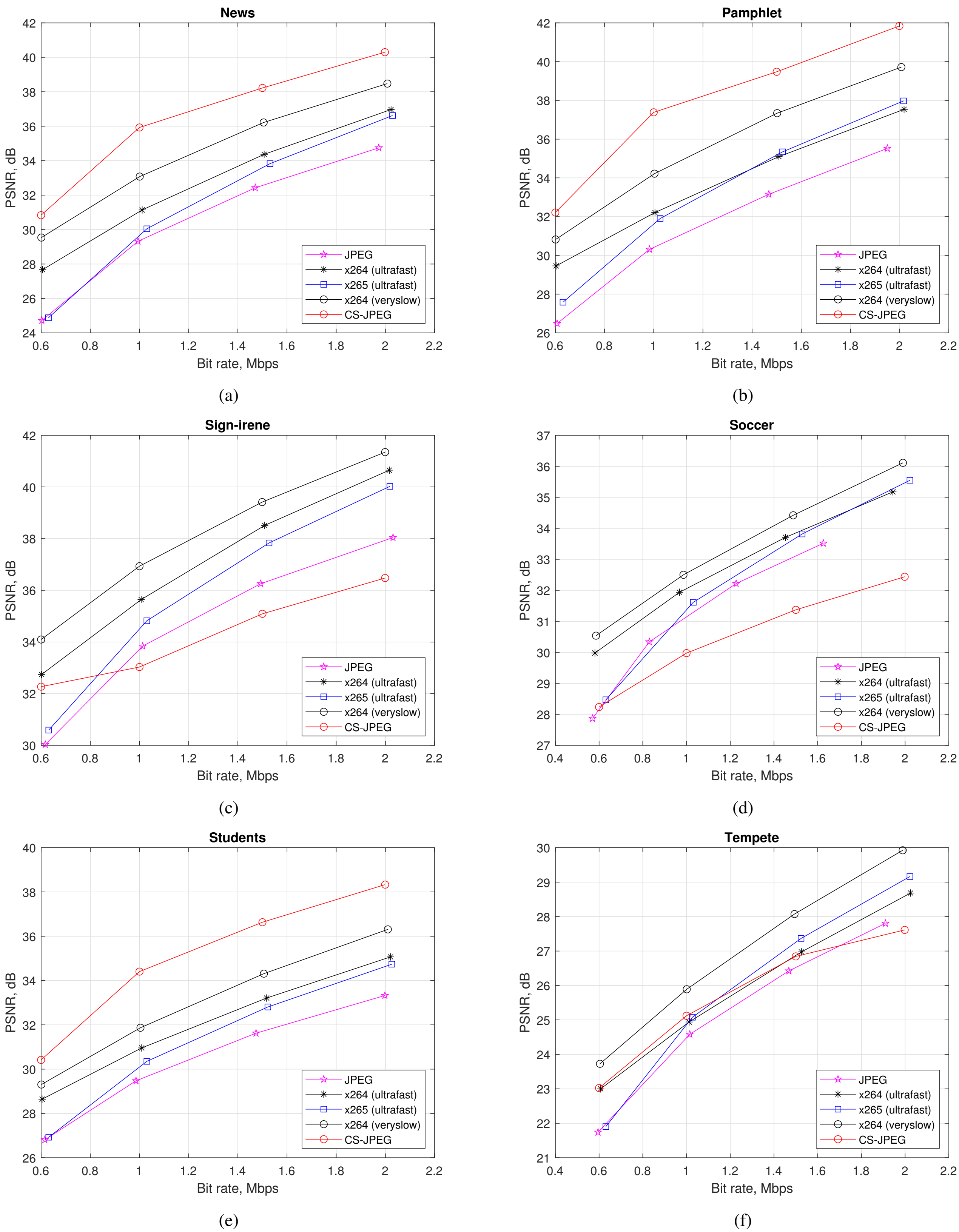
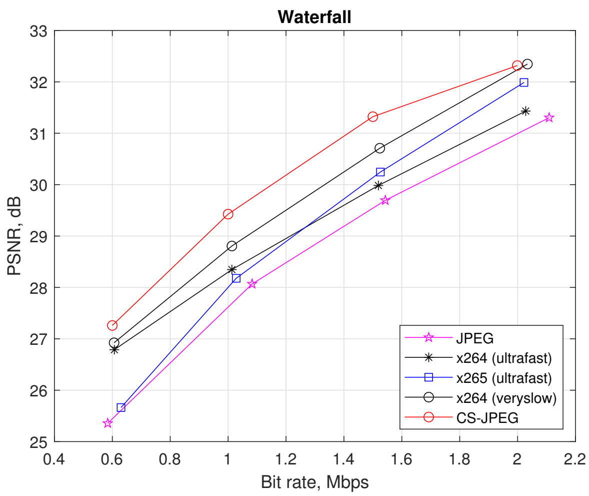
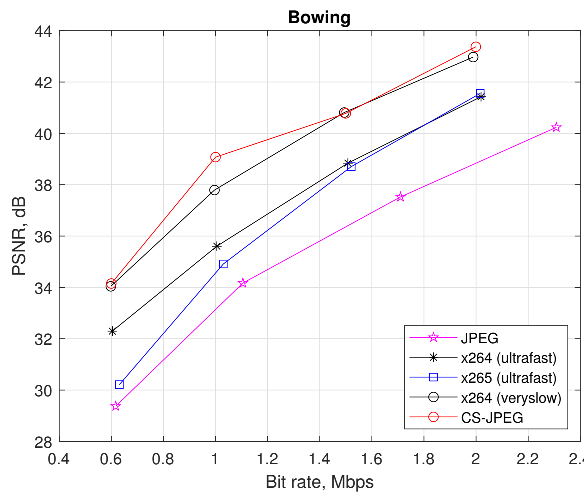


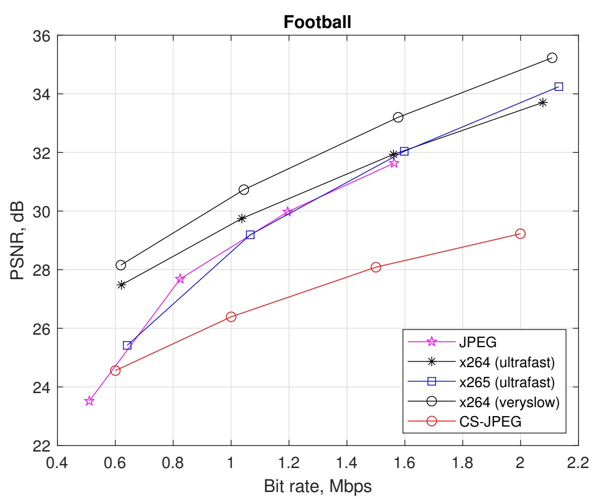
Fig. 4: Rate-distortion comparison of video codecs with intra-frame encoding



(a)



(b)



(c)

Fig. 5: Rate-distortion comparison of video codecs with intra-frame encoding