Adaptive intra mode bit skip in Intra coding

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INTRODUCTION

- At the last meeting, **an adaptive intra mode bit skip method** was proposed for improving intra coding performance.
  - Average bit saving under common test conditions : 2.5%
  - Average encoding time saving : 28%(QP=27), 45%(QP=32)
  - Average bit saving at low bitrates (information) : 6.14%

- The purpose of this contribution is to provide more simulation results.
  - Various sequences.
  - used with MDDT (Mode-Dependent Directional Transform)
    - MDDT : 4.1% bitsaving
    - MDDT + proposed : 6.1% bit saving

INTRODUCTION

- Intra4×4 mode provides 9 prediction modes for every 4×4 block.
  - Each MB coded as Intra4x4 mode needs 16~64bits to represent the modes.

- To reduce that burden, an **adaptive intra mode bit skip method** is proposed.
  - Coding efficiency is improved.
  - Encoding complexity is reduced.

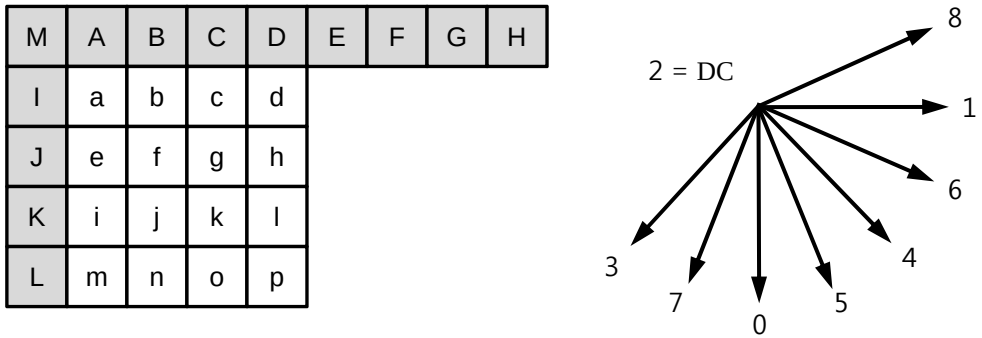


Fig. 1. Intra4×4 block and its directional prediction

Intra mode bit skip (Intra4×4 Mode)

- **Motivation**
  - If all block boundary pixels have the same value N, (refer to Fig. 2)
    - The prediction values of 9 prediction modes are same.
    - 4*x*4 residual block is always same independent of all modes.
      - 4*x*4 quantized block coefficients are also same.
  - It is not needed to use 9 prediction modes, i.e. only 1 mode is needed.
  - If all block boundary prediction pixel values are quite similar,
    - The 9 prediction modes are not needed, only DC mode can be used.

N	N	N	N	N	N	N	N	N
N	a	b	c	d				
N	e	f	g	h				
N	i	j	k	l				
N	m	n	o	p				

Fig. 2. In case that the adjacent pixels for prediction have the same value

Intra mode bits skip (Intra4×4 Mode)

- **Algorithm description**

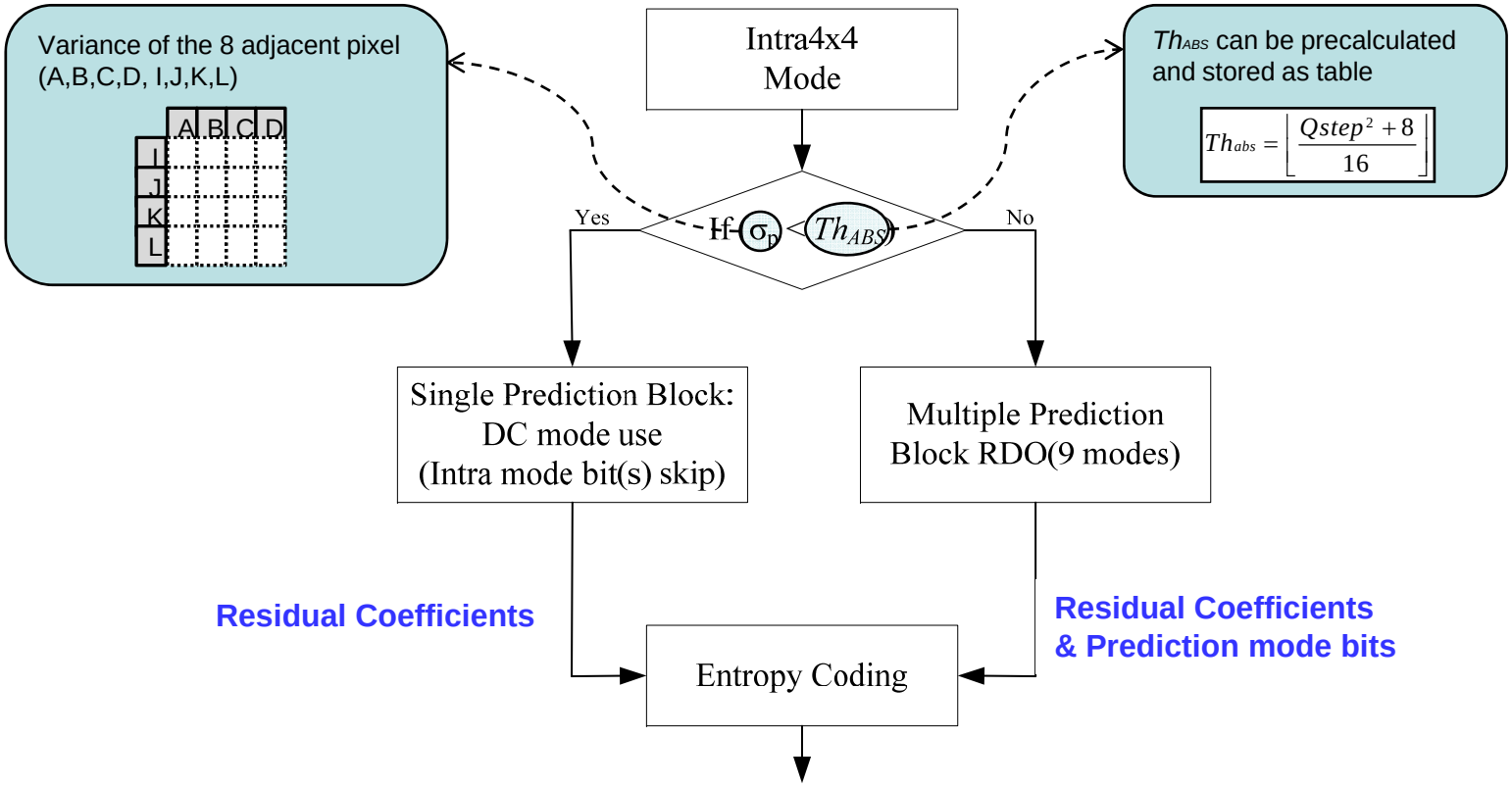


Fig. 3. The flowchart of the proposed method

Intra mode bits skip (Intra4×4 Mode)

- **Mode number reordering**
  - The probability of DC mode is very low at multiple prediction block (most of DC block modes are decided to single prediction block.)

Table 1. Prediction Mode Reordering for Multiple Prediction Block

Prediction Mode Number	H.264	Proposed Method	
		Single Prediction Block	Multiple Prediction Block
0	Vertical	-	Vertical
1	Horizontal	-	Horizontal
2	***DC***	-	Diagonal Down Left
3	Diagonal Down Left	-	Diagonal Down Right
4	Diagonal Down Right	-	Vertical Right
5	Vertical Right	-	Horizontal Down
6	Horizontal Down	-	Vertical Left
7	Vertical Left	-	Horizontal Up
8	Horizontal Up	-	***DC***

Intra mode bits skip (Intra4×4 Mode)

- **Bit-stream format change**
  - Because the decoder cannot distinguish the proposed Intra prediction modes bits and CBP & Coefficients bits.

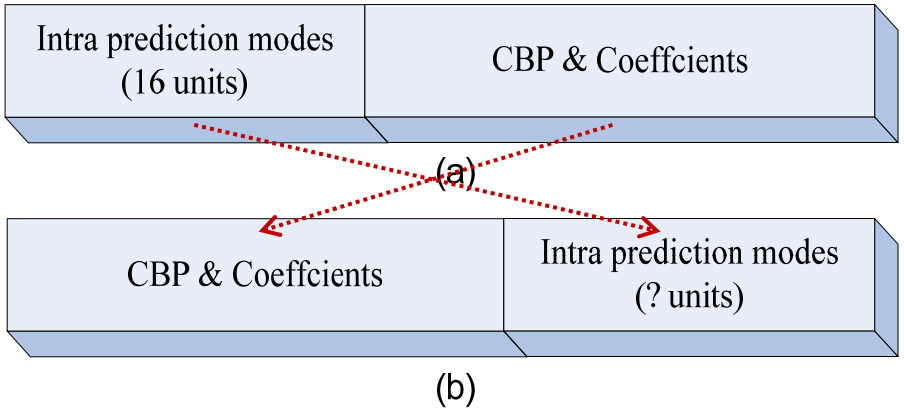


Fig. 4. Intra4×4 mode bit-stream: (a) H.264, (b) Proposed method

Intra mode bits skip (Chroma Intra)

- **Chroma Intra 8×8 mode**
  - The proposed method is also applied using similar way as that of Intra4×4 mode.

Experimental results

- **Conditions**
  - Implemented on KTA 1.9r1
  - Only Intra coding under the common test conditions (VCEG-AH10r3)
  - Baseline profile (CAVLC)

- **Evaluation**
  - BD-Rate (based on the VCEG-AI11)

Experimental results (coding efficiency)

- **Coding efficiency results under the common test conditions**

Sequence	Resolution	Frame Rate	Number of frames	Bit[1] (%)	Bit high[2] (%)	Bit low[3] (%)
Container	QCIF (176x144)	15	150	-1.42	-0.62	-2.48
Foreman		15	150	-3.36	-1.07	-6.41
Silent		15	150	-1.21	-0.28	-2.84
Average coding efficiency for QCIF				**-2.00**	**-0.66**	**-3.91**
Paris	CIF (352x288)	15	150	-2.96	-1.15	-5.53
Foreman		30	300	-0.52	-0.14	-1.04
Mobile		30	300	-1.07	-0.43	-1.95
Tempete		30	260	-0.81	-0.41	-1.38
Average coding efficiency for CIF				**-1.34**	**-0.53**	**-2.48**
Bigships	HD (1280x720)	60	150	-3.19	-1.06	-6.29
City		60	150	-1.48	-0.30	-3.32
Crew		60	150	-4.45	-2.92	-6.51
Night		60	150	-1.84	-0.72	-3.39
Shuttlestart		60	150	-4.64	-2.59	-7.06
Rolling Tomato	Full HD (1920x1080)	60	60	-5.58	-3.52	-7.11
Average coding efficiency for HD				**-3.53**	**-1.85**	**-5.62**
Average				**-2.50**	**-1.17**	**-4.26**

- [1]Bit (%) : BD-Rate over the whole range; [2]Bit high (%) : BD-Rate at high bit-rate; [3]Bit low (%) : BD-Rate at low bit-rate

Experimental results (coding efficiency)

- **Coding efficiency under the common test conditions with MDDT (Mode-Dependent Directional Transform)**

Sequence	Resolution	Frame Rate	Number of frames	MDDT Only (BD-rate)			Proposed& MDDT (BD-rate)		
				Bit (%)	Bit high (%)	Bit low (%)	Bit (%)	Bit high (%)	Bit low (%)
Container	QCIF (176x144)	15	150	-4.73	-4.55	-4.92	-6.14	-5.27	-7.07
Foreman		15	150	-5.47	-5.87	-4.62	-8.10	-6.65	-9.87
Silent		15	150	-5.03	-5.02	-4.83	-5.23	-5.03	-5.56
Average coding efficiency for QCIF				**-5.08**	**-5.14**	**-4.79**	**-6.49**	**-5.65**	**-7.50**
Paris	CIF (352x288)	15	150	-4.30	-4.80	-3.43	-6.73	-5.64	-8.12
Foreman		30	300	-4.26	-3.50	-4.99	-4.42	-3.51	-5.40
Mobile		30	300	-4.60	-4.28	-4.83	-5.30	-4.47	-6.22
Tempete		30	260	-4.33	-4.25	-4.19	-4.80	-4.48	-4.98
Average coding efficiency for CIF				**-4.37**	**-4.21**	**-4.36**	**-5.31**	**-4.53**	**-6.18**
Bigships	HD (1280x720)	60	150	-4.61	-5.81	-3.24	-7.30	-6.54	-8.71
City		60	150	-4.62	-5.62	-3.30	-5.61	-5.77	-5.72
Crew		60	150	-2.95	-3.24	-2.51	-6.68	-5.89	-7.79
Night		60	150	-4.11	-4.53	-3.37	-5.52	-5.10	-6.05
Shuttlestart		60	150	-2.96	-3.52	-2.39	-6.63	-5.59	-7.96
Rolling Tomato	Full HD (1920x1080)	60	60	-1.91	-5.56	-0.08	-6.49	-5.78	-7.14
Average coding efficiency for HD				**-3.53**	**-4.71**	**-2.48**	**-6.37**	**-5.78**	**-7.23**
Average				**-4.14**	**-4.66**	**-3.59**	**-6.07**	**-5.36**	**-6.97**

Experimental results (coding efficiency)

- **Additional experimental results (information)**

Sequence	Resolution	Frame Rate	Number of frames	Bit[1] (%)	Bit high[2] (%)	Bit low[3] (%)
News	CIF (352x288)	15	150	-2.27	-1.23	-3.37
Soccer		15	150	-1.48	-0.15	-3.63
Lmd		15	150	-2.81	-0.97	-5.41
Hall monitor		15	150	-1.97	-0.96	-3.29
Highway		15	150	-4.45	-1.85	-7.17
Ice	4CIF (704x576)	30	300	-4.93	-3.09	-7.18
City		30	300	-1.33	-0.25	-2.99
Harbour		30	300	-0.49	-0.16	-0.98
Soccer		30	300	-2.22	-0.51	-4.81
Crew		30	300	-3.05	-1.72	-4.86

- [1]Bit (%) : BD-Rate over the whole range; [2]Bit high (%) : BD-Rate at high bit-rate; [3]Bit low (%) : BD-Rate at low bit-rate

Experimental results (encoding time)

- **Encoding time saving under the common test conditions**

Sequence	Resolution	Frame Rate	Number of frames	QP=22	QP=27	QP=32	QP=37
Container	QCIF (176x144)	15	150	11.85%	24.16%	39.94%	49.69%
Foreman		15	150	8.47%	19.83%	40.13%	56.17%
Silent		15	150	4.11%	9.57%	24.41%	49.06%
Average coding efficiency for QCIF				**6.11%**	**17.85%**	**34.83%**	**51.64%**
Paris	CIF (352x288)	15	150	11.23%	24.86%	48.07%	64.71%
Foreman		30	300	3.14%	7.06%	14.82%	25.76%
Mobile		30	300	6.70%	11.82%	22.58%	33.81%
Tempete		30	260	6.33%	9.09%	17.84%	37.26%
Average coding efficiency for CIF				**6.85%**	**13.21%**	**25.83%**	**40.39%**
Bigships	HD (1280x720)	60	150	15.21%	35.08%	60.73%	75.04%
City		60	150	5.76%	21.68%	56.29%	76.30%
Crew		60	150	35.35%	54.54%	69.54%	76.63%
Night		60	150	9.74%	20.79%	38.87%	55.85%
Shuttlestar t		60	150	35.94%	53.47%	69.88%	78.45%
Rolling To mato	Full HD (1920x1080)	60	60	46.13%	64.20%	76.40%	80.82%
Average coding efficiency for HD				**24.69%**	**41.63%**	**61.95%**	**73.85%**
Average				**15.38%**	**27.40%**	**44.58%**	**58.43%**

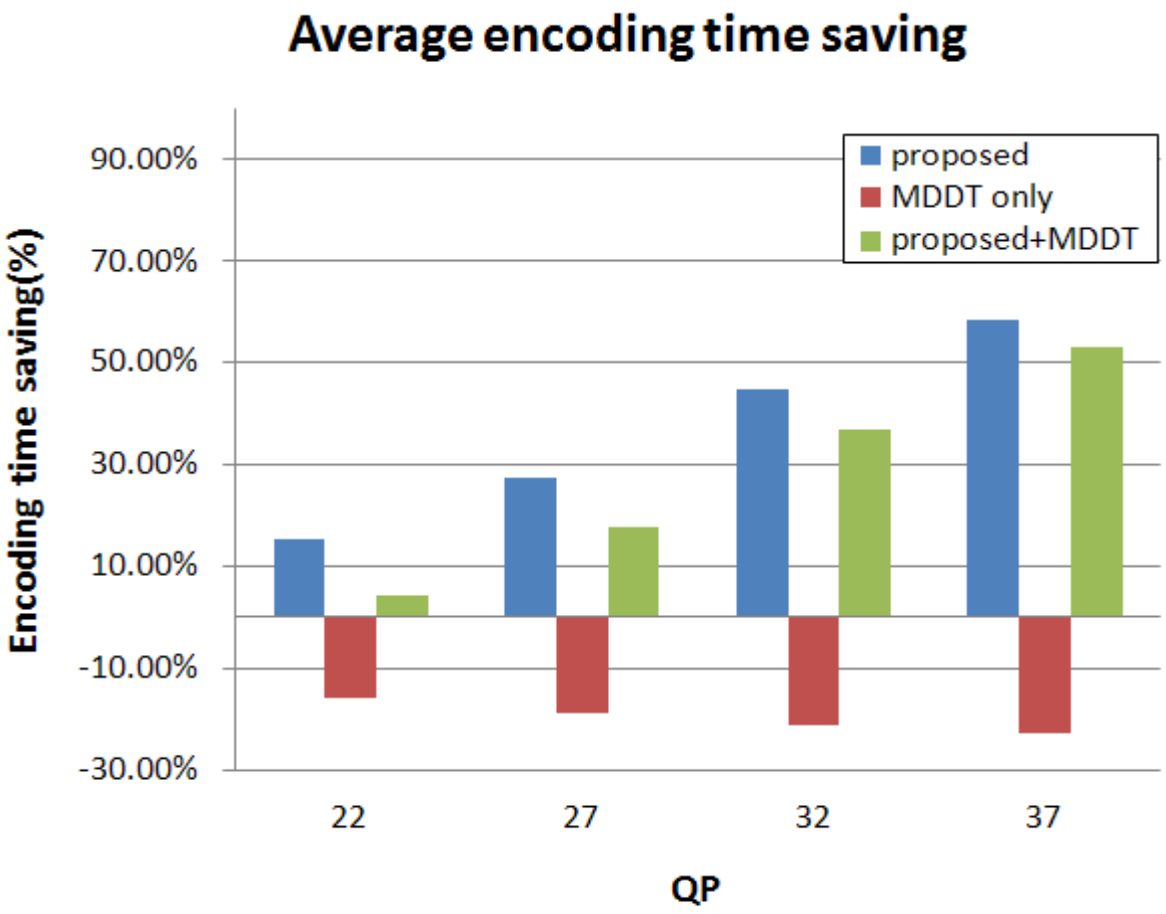
Experimental results (encoding time)

- **Encoding time saving under the common test conditions with MDDT**

Sequence	Resolution	Frame Rate	Number of frames	MDDT Only		Proposed& MDDT	
				QP=22	QP=37	QP=22	QP=37
Container	QCIF (176x144)	15	150	-14.16%	-22.42%	1.11%	42.78%
Foreman		15	150	-14.00%	-23.05%	-3.91%	51.01%
Silent		15	150	-12.81%	-22.31%	-8.73%	41.22%
Average coding efficiency for QCIF				**-10.24%**	**-22.59%**	**-2.88%**	**45.00%**
Paris	CIF (352x288)	15	150	-15.44%	-23.71%	-0.74%	60.25%
Foreman		30	300	-10.61%	-18.75%	-7.16%	14.58%
Mobile		30	300	-13.07%	-21.51%	-5.73%	23.79%
Tempete		30	260	-12.25%	-20.77%	-4.45%	27.23%
Average coding efficiency for CIF				**-12.84%**	**-21.19%**	**-4.52%**	**31.46%**
Bigships	HD (1280x720)	60	150	-17.11%	-24.49%	2.21%	72.68%
City		60	150	-15.31%	-23.10%	-8.06%	73.79%
Crew		60	150	-20.48%	-25.42%	27.11%	75.29%
Night		60	150	-16.38%	-23.26%	-2.67%	50.89%
Shuttlestart		60	150	-20.76%	-24.98%	27.84%	77.39%
Rolling Tomato	Full HD (1920x1080)	60	60	-24.59%	-25.09%	40.28%	80.46%
Average coding efficiency for HD				**-19.11%**	**-24.39%**	**14.45%**	**71.75%**
Average				**-15.92%**	**-22.99%**	**4.39%**	**53.18%**

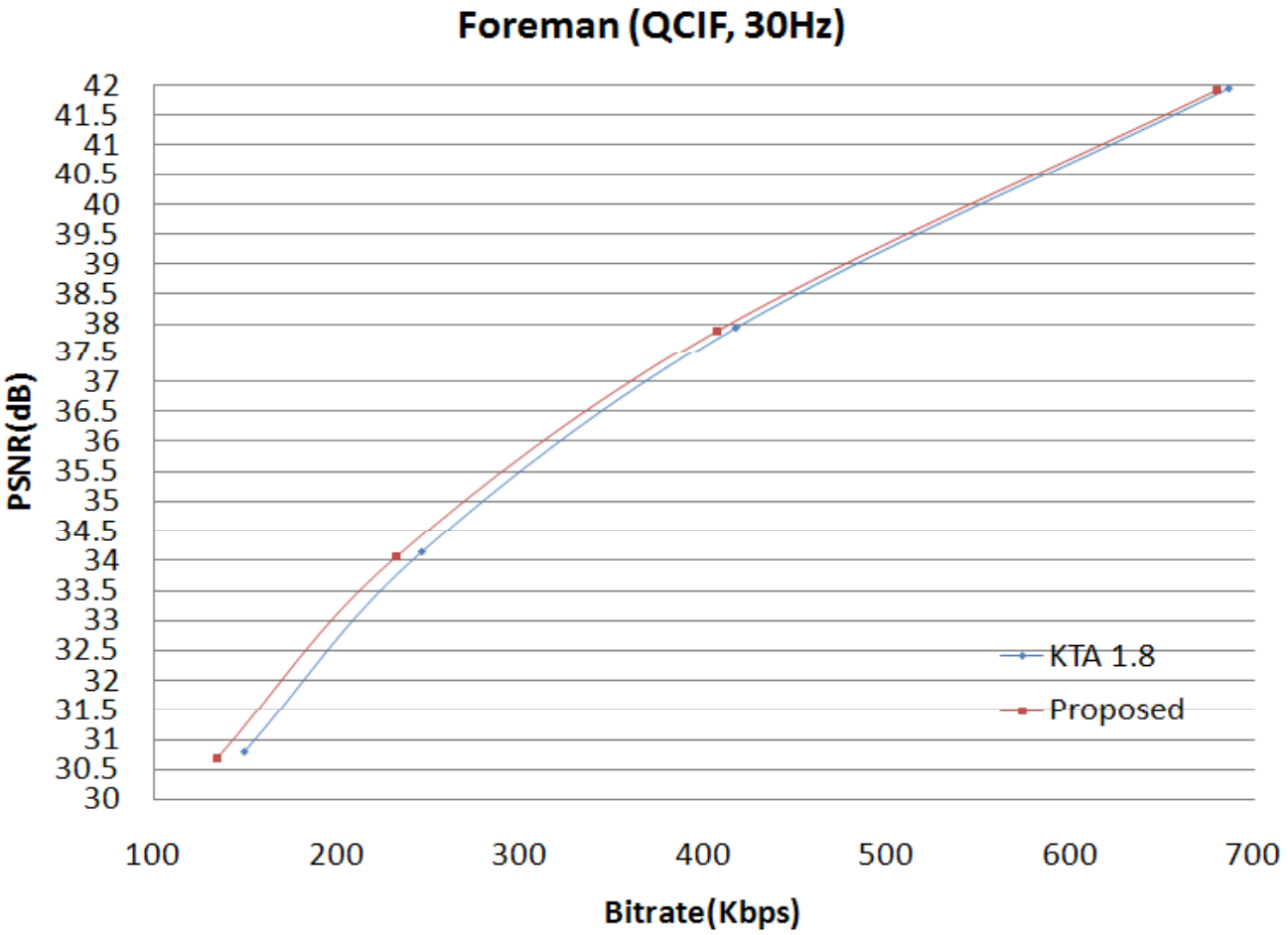
Experimental results (encoding time)

- **Encoding time saving under the common test conditions**



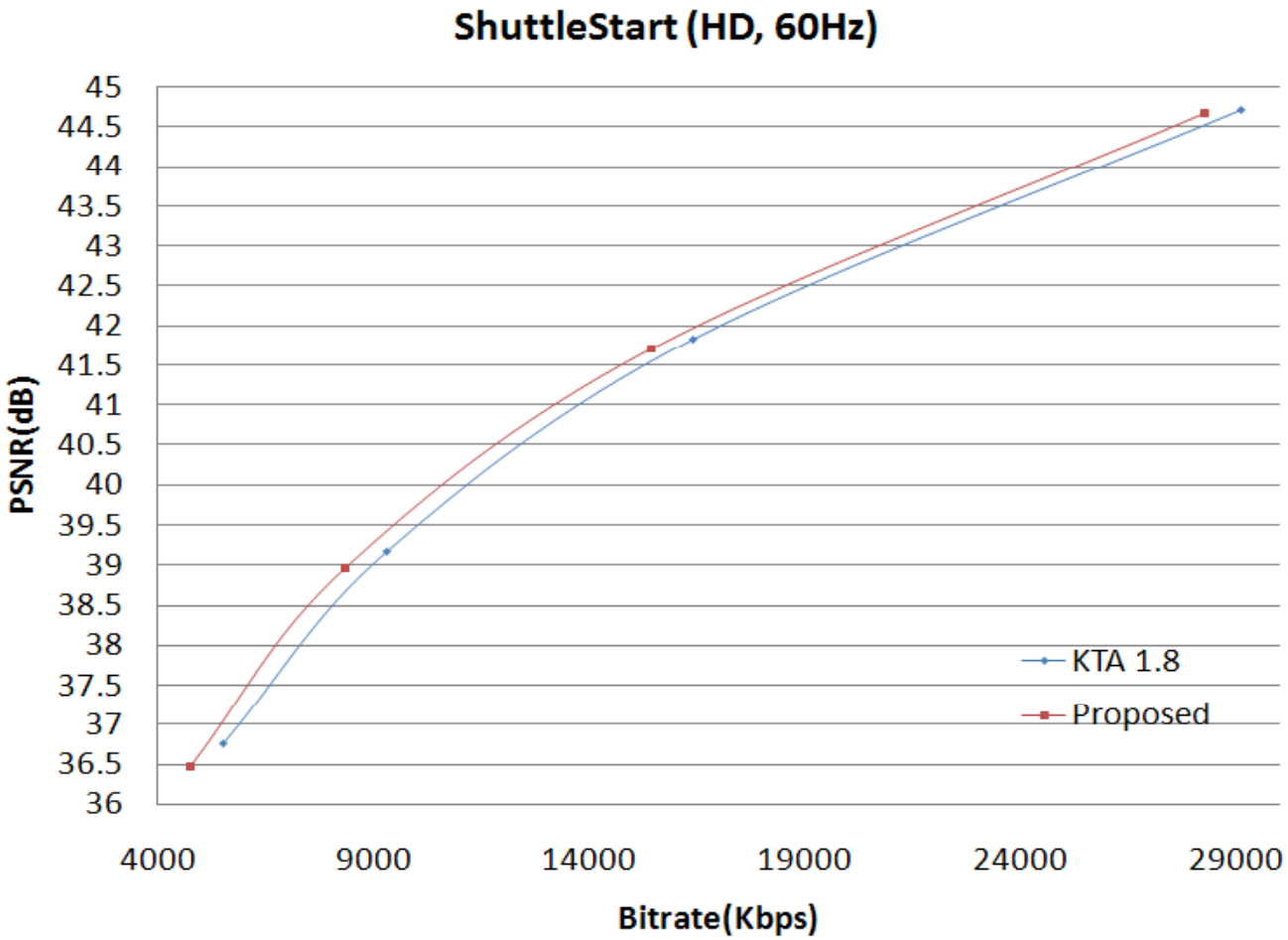
Experimental results (R-D curve)

- **R-D curve (Foreman, QCIF)**



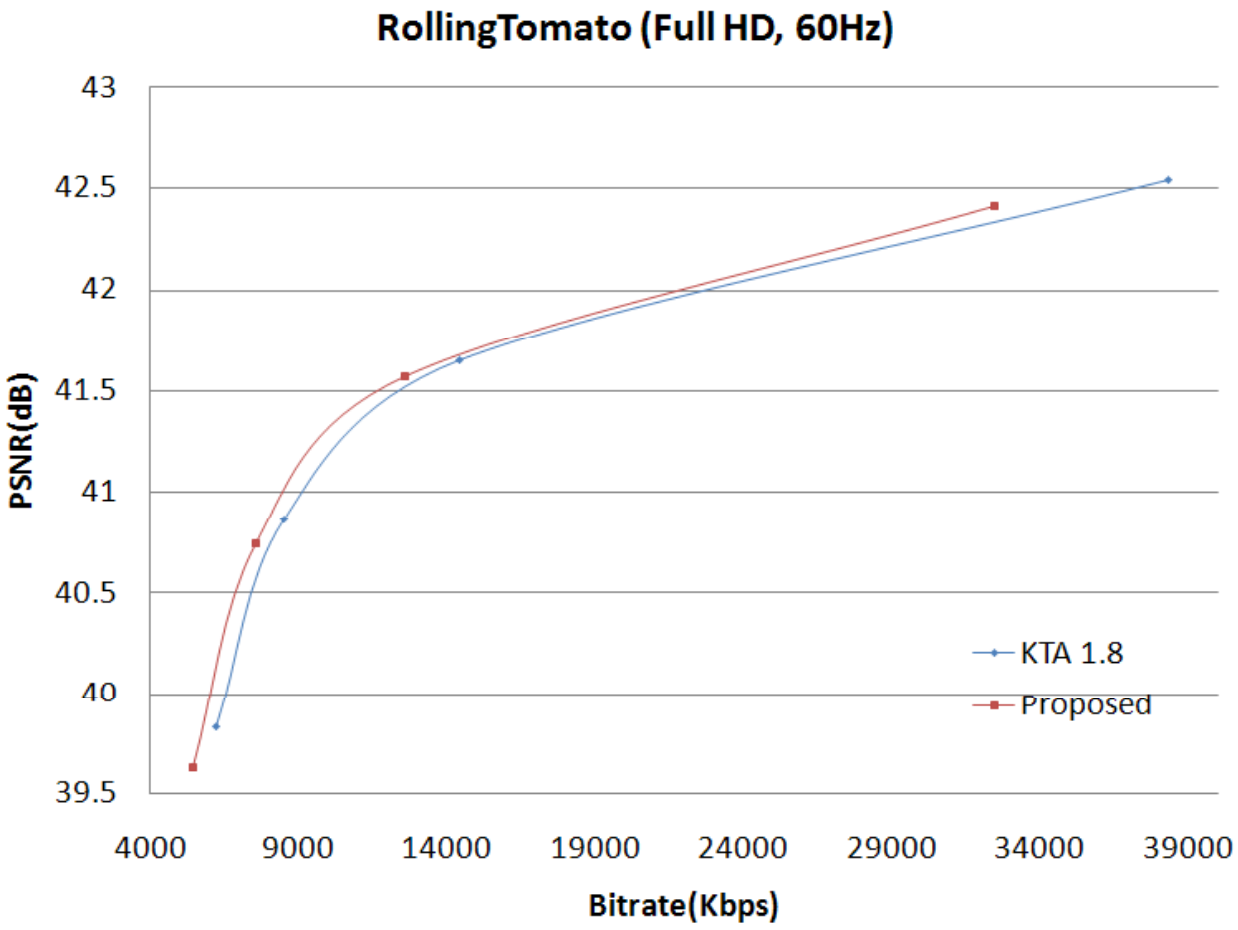
Experimental results (R-D curve)

- **R-D curve (ShuttleStart, HD)**



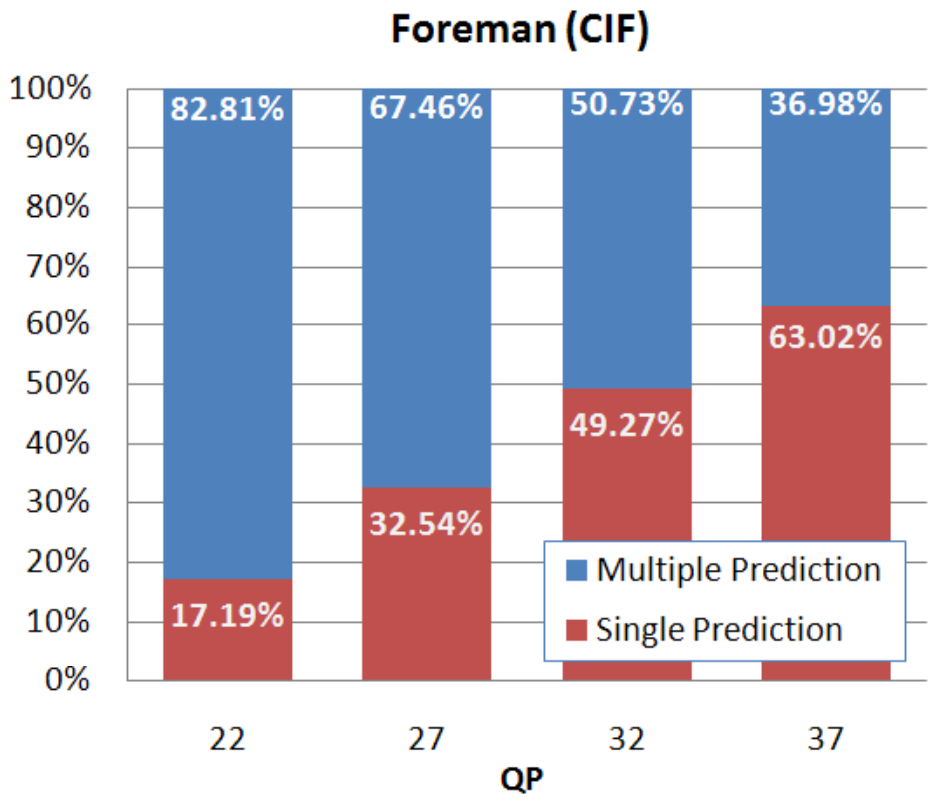
Experimental results (R-D curve)

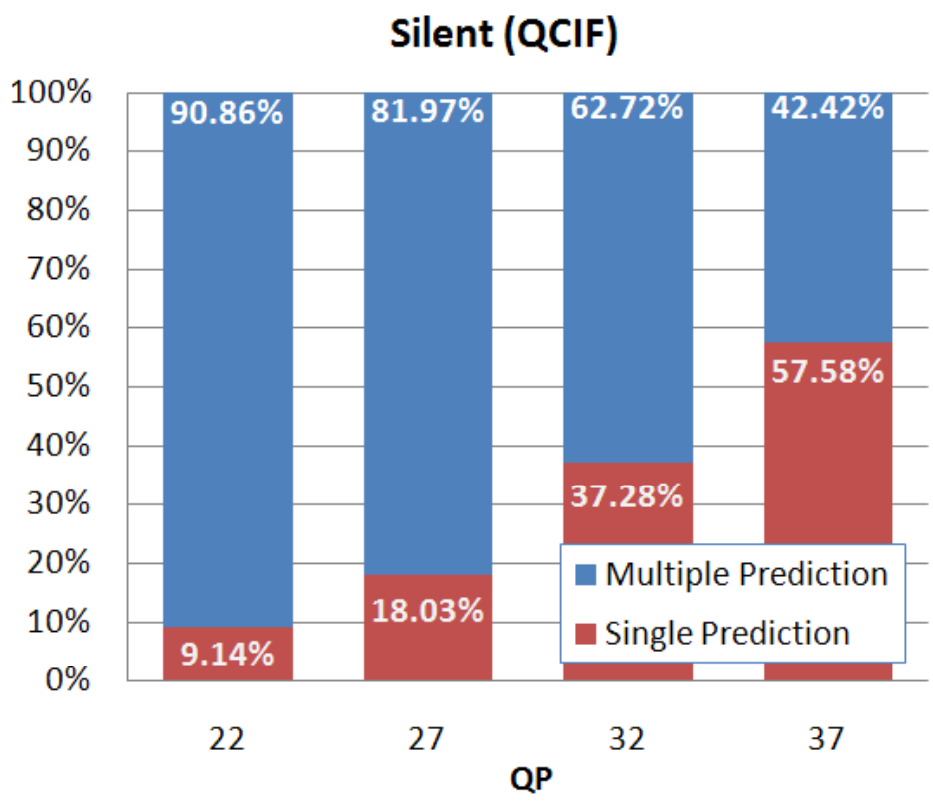
- **R-D curve (RollingTomato, Full HD)**



Experimental results

- The probability of the Single Prediction vs. that of the Multiple Prediction





Experimental results

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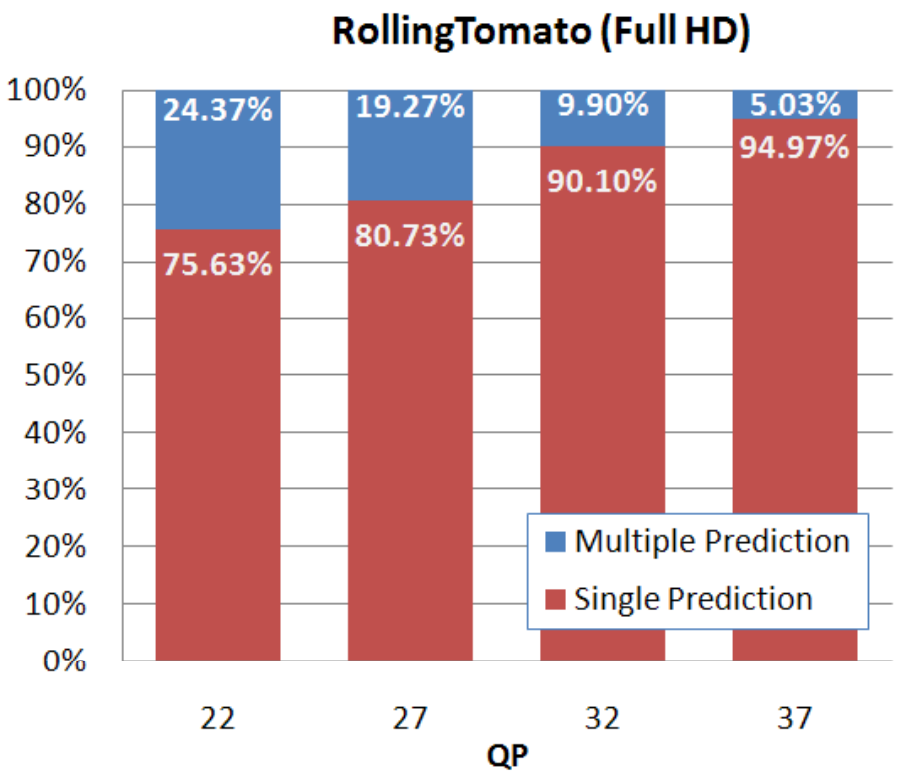

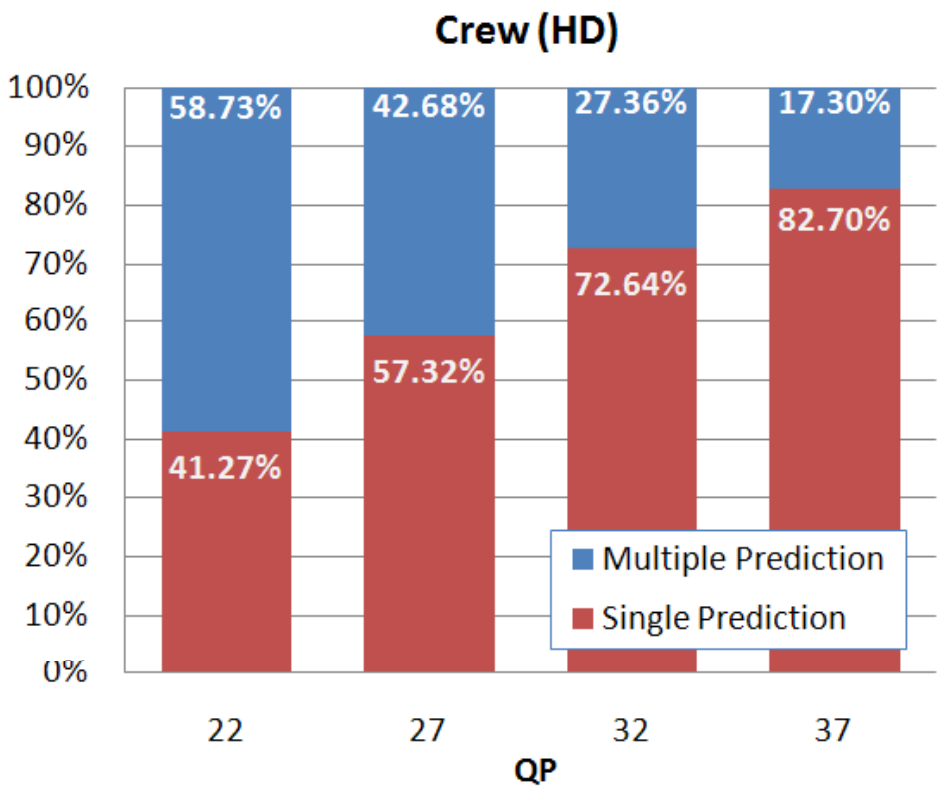

Conclusion

- **Adaptive Intra mode bits skip** is proposed to improve the intra coding performance.
  - Coding efficiency is improved
  - Encoder complexity is reduced

- **Coding efficiency**
  - Average bit-rate reduction of 2.5% is achieved under the common test conditions. (HD resolution : 3.5%, low bit-rate : 4.3%)
  - The proposed method + MDDT : 6.1% (MDDT : 4.1%)

- **Encoder complexity (encoding time saving)**
  - Average time saving : 27.4% (QP 27), 44.6% (QP 32), 58.4%(QP 37)
  - HD resolution : 41.6% (QP 27), 62.0% (QP 32), 73.9% (QP 37)