

西安电子科技大学

# HEVC ENCODER OPTIMIZATION BASED ON PERCEPTUAL BLOCK MERGING

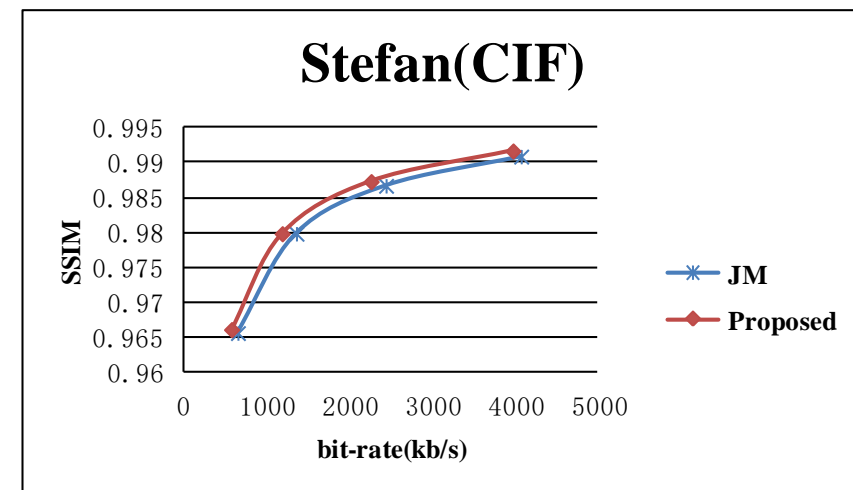
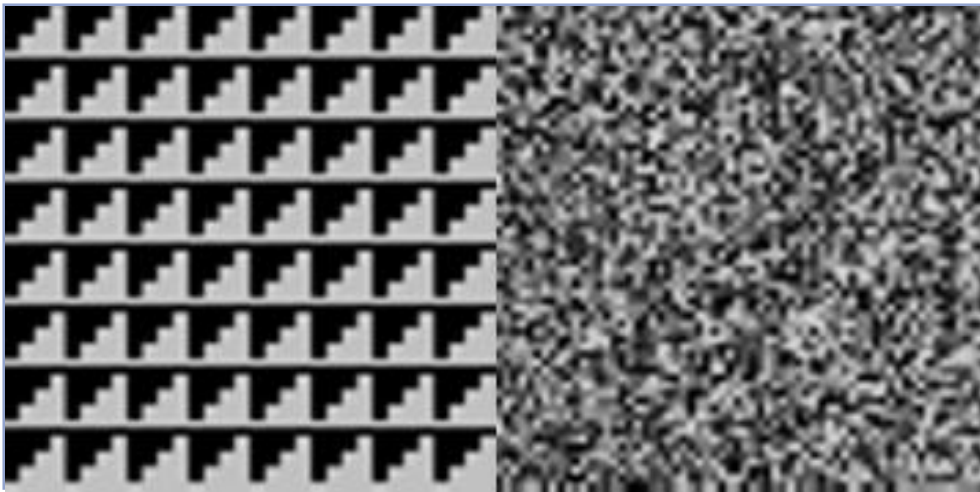
**JCTVC-X0070**

**Cheolkon Jung, Qiaozhou Lin, Shengtao Yu (Xidian Univ.)**

**Ming Li, Ping Wu (ZTE)**

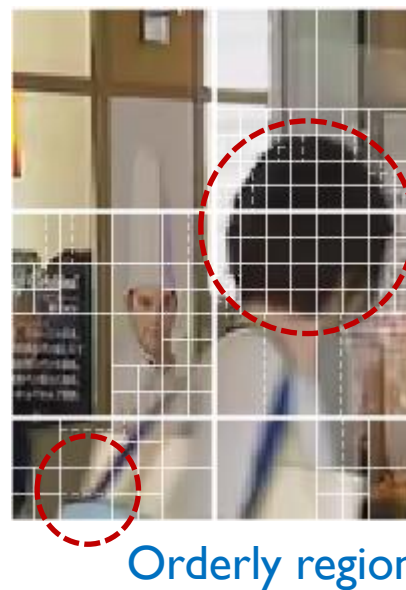
# FREE ENERGY-BASED JND (FEJND)

- **Free-energy principle:** HVS perceives orderly stimulus well, but tends to ignore details of disorderly regions (**Disorderly concealment effect**);
- Sensitivity depends on the orderliness  $\Rightarrow$  **Free energy-based JND model (FEJND)**
- \* **Perceptual block merging** achieves average bit-saving of **8.41%** in 8bit videos;





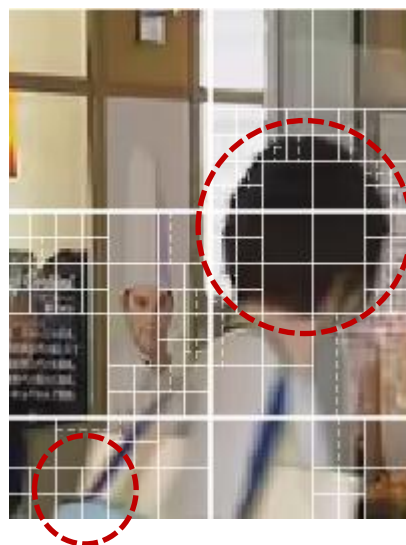
The 3<sup>th</sup> frame of sequence *BQMall*



Disorderly region

HM:  
Bits:7328  
PSNR:  
34.0524dB

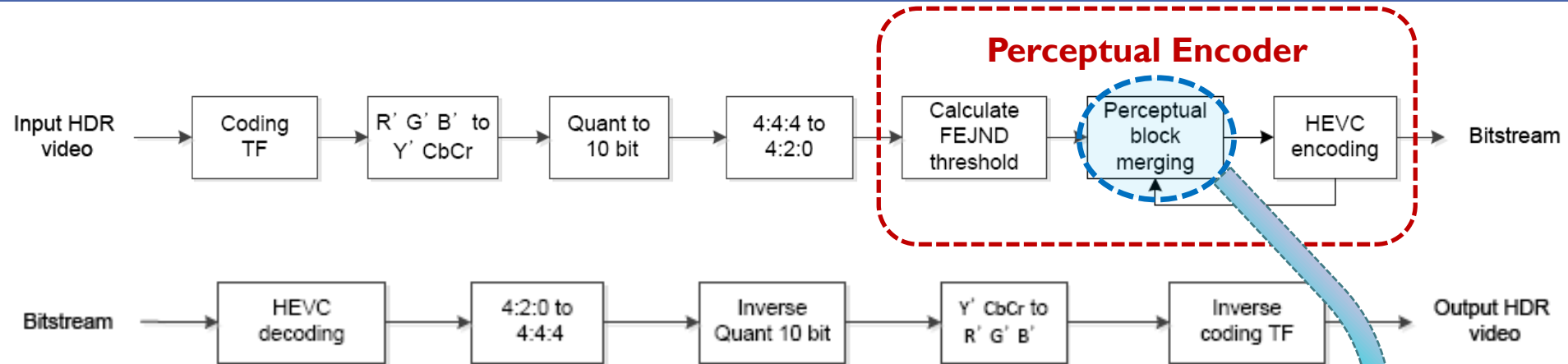
Orderly region



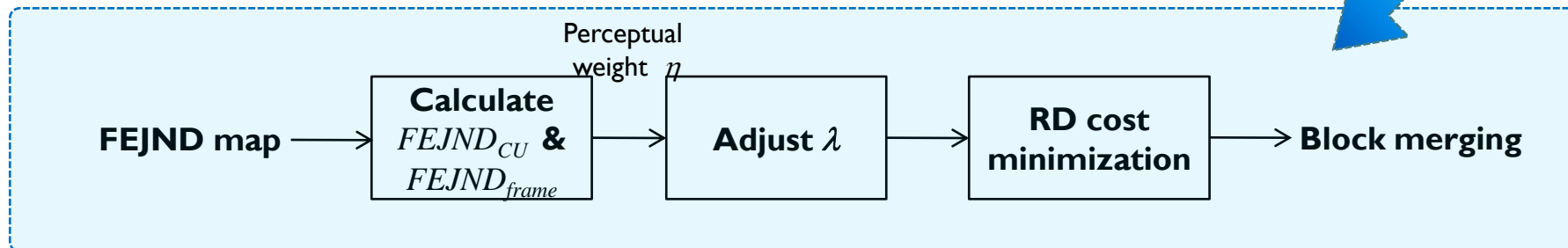
**QP=32**

Proposed:  
Bits:6928  
PSNR:  
34.0227dB

# HEVC ENCODER OPTIMIZATION



Whole Framework of the Proposed Method



Perceptual Block Merging



# PERCEPTUAL BLOCK MERGING

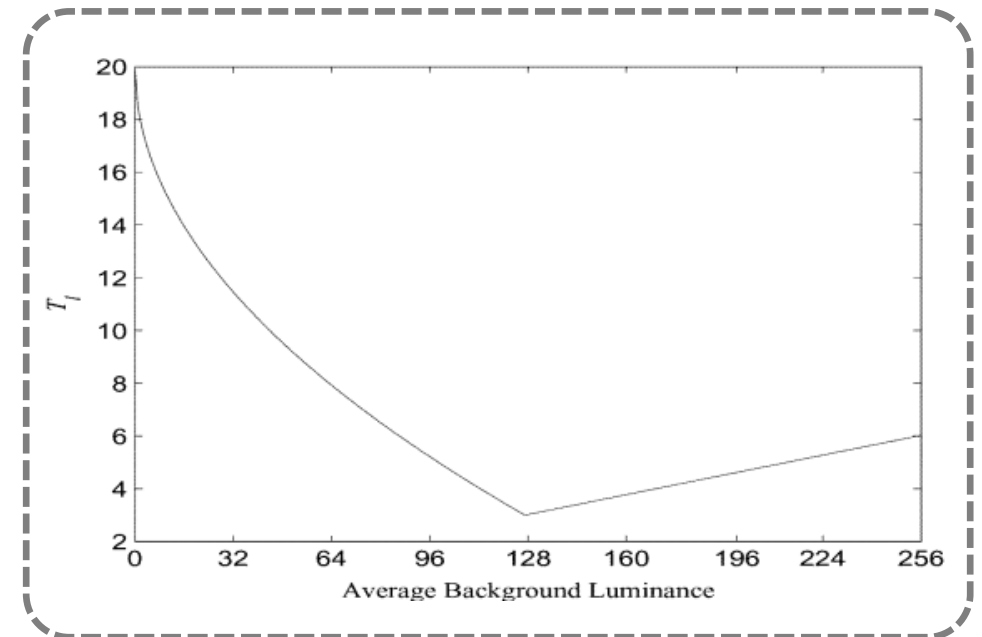
**m37073**

- FEJND map: Orderly JND + Disorderly JND
  - Orderly JND: **Luminance adaptation (LA)** + Spatial masking (SM)
  - Disorderly JND: Prediction residual using **autoregressive (AR)** model

$$JND_p(x, y) = LA(x, y) + SM(x, y) - 0.03 * \min\{LA(x, y), SM(x, y)\}$$

- **LA for 8bit LDR videos**

$$LA(x, y) = \begin{cases} 17 \left( 1 - \sqrt{\frac{I(x, y)}{127}} \right) + 3, & \text{if } \overline{I(x, y)} \leq 127 \\ \frac{3}{128} (\overline{I(x, y)} - 127) + 3, & \text{otherwise} \end{cases}$$



# PERCEPTUAL BLOCK MERGING

- FEJND map by 8bit LA (luminance) is not suitable for **PQ-transformed 10bit luma**:
  - 10bit luma from perceptually quantized luminance based on Barten CSF model;
  - Need to change LA for 10bit luma based on Barten CSF model;
- We propose **LA\*** for 10bit luma based on Barten CSF model:
  - 1<sup>st</sup> step: Map luma to luminance using inverse PQ\_TF:
$$lum = 10000 * inversePQ\_TF(range\_N)$$
  - 2<sup>nd</sup> step: Map luminance to JND based on Barten CSF model (**10bit LA**):

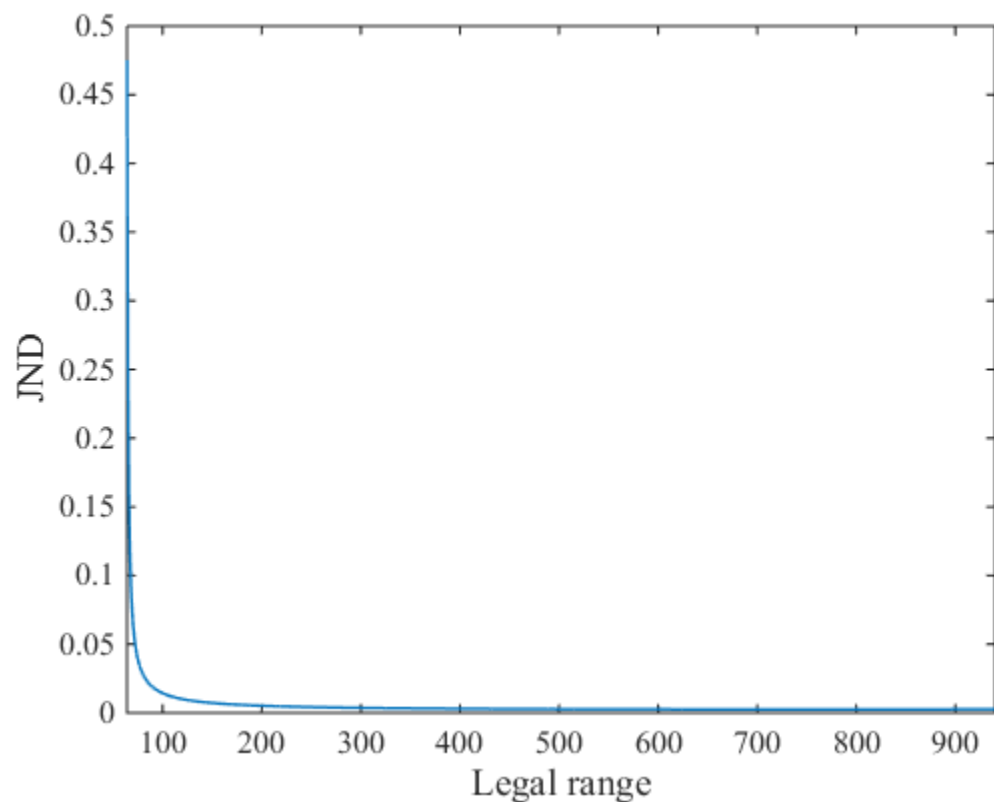
$$LA_{10}(j) = \begin{cases} \frac{lum(j+1) - lum(j)}{[lum(j+1) + lum(j)] / 2} * \frac{940 - 64}{0.9 \times 4096}, & j = 1, 2, \dots, 876 \\ \frac{lum(j) - lum(j-1)}{[lum(j) + lum(j-1)] / 2} * \frac{940 - 64}{0.9 \times 4096}, & j = 877 \end{cases}$$

**JCTVC-W0066**

**\*Luma Adaptation**

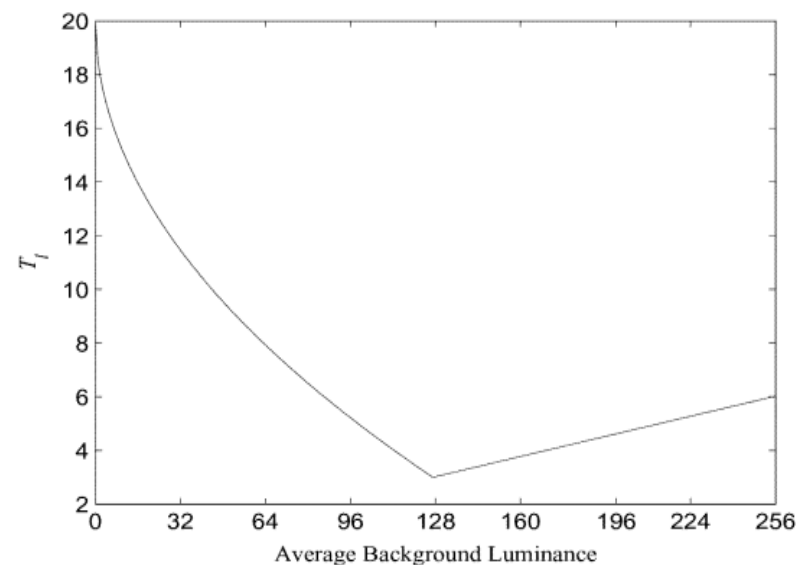
# PERCEPTUAL BLOCK MERGING

**JCTVC-W0066**



**Barten CSF-Based LA  
for 10-bit quantized HDR videos**

**m37073**



# EXPERIMENTAL RESULTS

## Experimental Setup

**JCTVC-X0070**

- **Test model:**  
HEVC Main 10 Profile (**HM16.7**) using sing **Random Access (RA)** configuration;  
Hierarchical B picture structure with a Group of Pictures (GOP) size of not larger than 8 frames according to **CTC**;
- **Anchor:** HM16.7 and the updated HDRTools 0.10 (HDRTools 0.10 with patch files);
- Hardware: Workstation with Intel Xeon E5-2640 v3 CPU (2.60GHZ and 8Cores) and 32.00GB RAM;
- Software: Windows 7 environment and Microsoft Visual Studio 2013



# EXPERIMENTAL RESULTS

## ■ **BD Rate Comparison** between Proposed Method and HMI6.7

		X	Y	Z	XYZ	tOSNR-XYZ	DE100	MD100	PSNRL100	PSNR Y	PSNR U	PSNR V
class A	FireEaterClip4000r1	3.2%	1.8%	3.0%	2.7%	5.2%	3.4%	-1.9%	0.2%	1.2%	6.1%	6.4%
	Market3Clip4000r2	-2.1%	-2.0%	-2.8%	-2.4%	-3.5%	-4.8%	-5.8%	-4.2%	-1.9%	-4.3%	-4.4%
	SunRise	-2.6%	-1.8%	-3.6%	-2.8%	-5.2%	-6.6%	-6.4%	-5.1%	-1.8%	-7.4%	-7.3%
class B	BikeSparklers cut 1	0.9%	1.0%	0.8%	0.9%	-0.6%	-1.6%	-1.2%	-0.4%	1.0%	-0.4%	-1.6%
	BikeSparklers cut 2	1.4%	1.6%	0.4%	1.2%	-0.7%	-2.4%	6.9%	-0.4%	1.6%	-0.8%	-2.3%
	GarageExit	0.4%	0.5%	-0.1%	0.2%	-0.9%	-1.6%	-0.4%	-1.0%	0.5%	-0.9%	-0.9%
class C	ShowGirl2Teaser	3.3%	2.7%	4.8%	3.7%	3.4%	6.3%	18.1%	1.4%	2.7%	7.2%	7.5%
class D	StEM_MagicHour cut 1	2.7%	1.7%	3.7%	3.0%	3.1%	4.7%	8.8%	1.2%	1.7%	5.1%	5.9%
	StEM_MagicHour cut 2	1.0%	0.7%	1.1%	0.9%	0.9%	1.5%	5.5%	-0.1%	0.7%	1.5%	3.0%
	StEM_MagicHour cut 3	1.1%	0.6%	2.2%	1.6%	1.8%	2.4%	-7.6%	-0.7%	0.6%	3.3%	3.9%
	StEM_WarmNight cut 1	2.9%	2.3%	2.8%	2.7%	3.1%	4.4%	0.4%	1.5%	2.2%	5.3%	5.5%
	StEM_WarmNight cut 2	4.8%	3.5%	4.4%	4.3%	4.5%	5.6%	3.8%	2.8%	3.0%	6.2%	8.1%
class G	BalloonFestival	-0.7%	0.6%	-2.5%	-1.2%	-5.6%	-8.2%	1.5%	-5.1%	0.8%	-7.0%	-7.2%
class H	EBU_04_Hurdles	-0.3%	-0.1%	-1.2%	-0.7%	-1.7%	-2.4%	-9.9%	-1.8%	-0.1%	-2.1%	-2.1%
	EBU_06_Start	-1.8%	-1.2%	-2.5%	-2.0%	-3.3%	-5.0%	0.9%	-3.7%	-1.1%	-3.5%	-3.7%
	<b>Overall</b>	0.9%	0.8%	0.7%	0.8%	0.0%	-0.3%	0.8%	-1.0%	0.7%	0.6%	0.7%

# EXPERIMENTAL RESULTS

## ■ Runtime Comparison between Proposed Method and HMI6.7

		QP Slice	Enc T [s]	Enc T [h]	Enc T [s]	Enc T [h]
class A	FireEaterClip4000r1 S00	18	12197.71	3.39	12853.91	3.57
		22	10790.74	3.00	11678.86	3.24
		25	10682.38	2.97	11513.70	3.20
		28	10619.91	2.95	11420.47	3.17
	Market3Clip4000r2 S02	22	21908.77	6.09	23484.72	6.52
		29	19144.88	5.32	21363.63	5.93
		32	18731.28	5.20	20776.47	5.77
		34	18438.97	5.12	20456.54	5.68
	SunRise S12	18	8645.51	2.40	9324.02	2.59
		21	8282.82	2.30	9056.52	2.52
		25	7963.30	2.21	8698.86	2.42
		29	7884.93	2.19	8529.45	2.37
class B	BikeSparklers cut 1 S04	22	7479.12	2.08	7979.88	2.22
		24	6923.95	1.92	7429.02	2.06
		29	6150.55	1.71	6752.34	1.88
		33	5765.34	1.60	6311.76	1.75
	BikeSparklers cut 2	22	8821.79	2.45	9430.23	2.62
		24	8283.05	2.30	8816.07	2.45
		29	7499.47	2.08	8093.84	2.25
		33	7103.36	1.97	7710.04	2.14
	GarageExit S13	21	17886.37	4.97	19538.29	5.43
		25	15501.62	4.31	16266.40	4.52
		30	15217.74	4.23	16964.95	4.71
		34	13987.19	3.89	13835.52	3.84
class C	ShowGirl2Teaser S05	19	22584.30	6.27	26523.01	7.37
		24	19142.90	5.32	21453.98	5.96
		28	17631.62	4.90	21957.11	6.10
		32	16805.18	4.67	21073.73	5.85

class D	StEM_MagicHour cut 1 S06	18	5491.78	1.53	6397.72	1.78
		22	4825.57	1.34	5528.43	1.54
		27	4504.60	1.25	5121.94	1.42
		31	4131.84	1.15	5531.74	1.54
	StEM_MagicHour cut 2	18	19608.05	5.45	21339.58	5.93
		22	17716.92	4.92	18842.59	5.23
		27	15723.55	4.37	17415.25	4.84
		31	12304.74	3.42	15292.32	4.25
	StEM_MagicHour cut 3	18	7089.16	1.97	7648.66	2.12
		22	5620.49	1.56	7250.74	2.01
		27	4787.76	1.33	5201.66	1.44
		31	4292.71	1.19	4355.84	1.21
	StEM_WarmNight cut 1 S07	18	11882.13	3.30	13147.05	3.65
		23	10091.84	2.80	11716.04	3.25
		27	9598.20	2.67	10715.18	2.98
		31	7935.75	2.20	8883.75	2.47
StEM_WarmNight cut 2	18	8637.39	2.40	9628.42	2.67	
	23	6936.64	1.93	7885.07	2.19	
	27	7004.59	1.95	7811.50	2.17	
	31	6027.44	1.67	6712.93	1.86	
class G	BalloonFestival S08	22	16500.92	4.58	19329.57	5.37
		26	15849.53	4.40	18505.53	5.14
		29	14855.59	4.13	17756.16	4.93
		31	15147.51	4.21	17801.20	4.94
class H	EBU_04_Hurdles S10	23	34791.38	9.66	36622.27	10.17
		27	32515.40	9.03	35017.40	9.73
		32	31338.83	8.71	33398.86	9.28
		36	30599.66	8.50	32771.15	9.10
	EBU_06_Start S11	22	23450.92	6.51	24897.92	6.92
		26	22599.66	6.28	23360.70	6.49
		32	22011.04	6.11	23603.71	6.56
		36	21836.49	6.07	23329.82	6.48
	Time geomean			3.21		3.56
	Time ratio					111%
	Time sum (hours)			224.38		247.81

**Increases 11%  
over HMI6.7!!**

: Mainly caused by getting  
disorderly maps

Market



QP=34

Proposed



Market



QP=34

HMI6.7





QP=34

Proposed



QP=34

HMI6.7



Hurdles



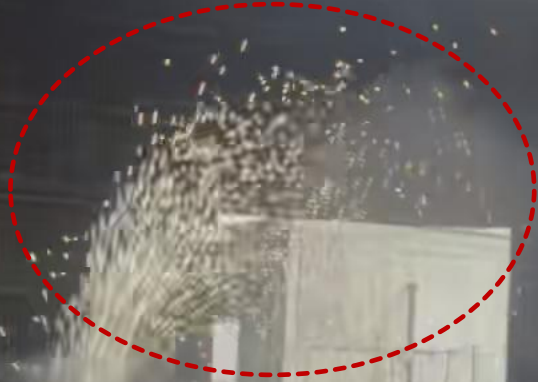
QP=36  
Proposed



Hurdles



QP=36  
HMI6.7



QP=31

Proposed





QP=31  
HMI6.7



QP=31

Proposed





QP=31

HMI6.7



# CONCLUSIONS

- We have proposed **perceptual block merging** for **HEVC Main 10 Profile-based HDR video coding**.
  - Obtain **10bit LA based on Barten CSF** to generate the FEJND map;
  - Compute **perceptual Lagrange multiplier** in each CU for RDO based on the FEJND map,;
  - Perform **perceptual block merging** by minimizing RD costs.
- **Experimental results:**
  - Achieve **better BD-rate performance** than HM16.7 in most test sequences;
  - Need **more bits** to maintain visual quality in some **test sequences with a dark tone**;
  - **11% runtime increase** over HM16.7;
  - **General encoding** technique that can be applied to various contexts;
- **Future plans:**
  - **Investigate JND models** for HDR video coding which are fast, simple, and more suitable for human visual perception;
  - Perform comparative analysis with **QP adjusting techniques** such as luma delta QP and chroma QP offset;

# THANK YOU!



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