

CE6.a: Chroma intra prediction by reconstructed luma samples

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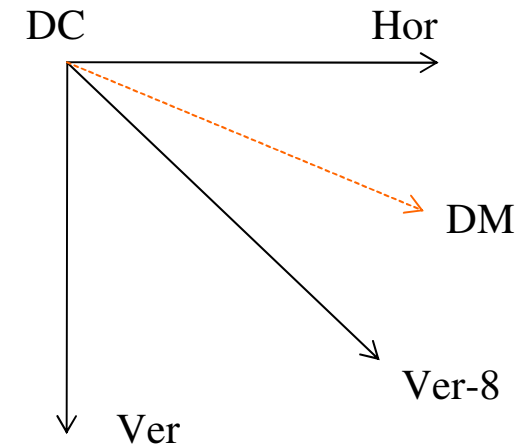
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Introduction

❖ Chroma intra prediction in HEVC Test Model

- Vertical,
- Horizontal,
- DC
- Vertical-8: Diagonal down-right
- DM mode: using Luma UDI mode



- ## ❖ The prediction scheme is not sufficient enough for complex texture area with vivid color information



Proposed method -- 1

❖ Motivation

- Shape and texture pattern is similar between Luma and chroma signals in many cases
- Utilizes the inter-channel correlation to improve chroma intra prediction efficiency

❖ Solution

- Predict chroma from reconstructed luma samples of same block with linear model

$$Pred_C[x, y] = \alpha \cdot Rec_L[x, y] + \beta$$

- Derive model parameters *alpha* and *beta* by using neighboring reconstructed luma and chroma data with least square solution

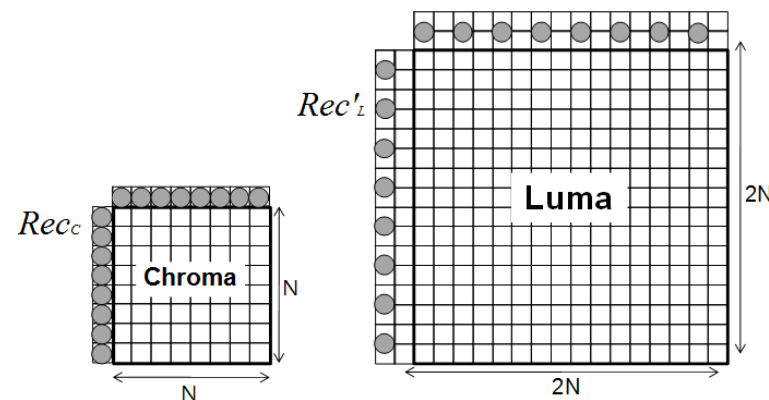


Proposed method -- 2

- ❖ Parameters α and β is calculated with reconstructed neighboring luma and chroma data: **least square solution**

$$\alpha = \frac{I \cdot \sum_{i=0}^I Rec_C(i) \cdot Rec_L'(i) - \sum_{i=0}^I Rec_C(i) \cdot \sum_{i=0}^I Rec_L'(i)}{I \cdot \sum_{i=0}^I Rec_L'(i) \cdot Rec_L'(i) - \left(\sum_{i=0}^I Rec_L'(i) \right)^2} = \frac{A_1}{A_2}$$

$$\beta = \frac{\sum_{i=0}^I Rec_C(i) - \alpha \cdot \sum_{i=0}^I Rec_L'(i)}{I}$$



- I is equal to $2N$, where N is blockSize
- Approximately, $3N$ multiplication and $6N$ addition is used to calculate α and β for one $N \times N$ chroma block, the operation number is negligible if accounting it for each pixel
- Use table lookup and multiplication instead of division to calculate α
- All multiplication and division operation related to I can be replaced by shift since I is power of 2
- Multiplier data range is less than 16 bits in all operation

$$pred_C[x, y] = (\alpha' \cdot Rec_L'[x, y] \gg n_\alpha) + \beta'$$

Integration to HEVC Test Model

- ❖ Integration on the top of HEVC TMuC0.9 software
 - LM5mode: Proposed LM mode replacing Vertical-8 mode
 - Vertical-8 has smallest mode proportion
 - LM3mode: LM, DM, DC
 - LM and DM can implicitly represent other mode

mode code-word	TMuC 0.9	LM5mode	LM3mode
0	Vertical	LM	LM
10	Horizontal	DM	DM
110	DC	Vertical	DC (11)
1110	Vertical-8	Horizontal	
1111	DM	DC	

Experimental results -- 1

- 6 Common test configurations
- LM5Mode
 - 1.4%, 6.5% and 5.2% in intra configuration,
 - 0.7%, 5.8% and 3.7% in random access configuration,
 - With same encoding/decoding time
- LM3Mode
 - 1.3%, 6.3% and 4.9% in intra configuration,
 - 0.6%, 5.4% and 3.3% in random access configuration,
 - With 5% encoding time reduction

<i>Test configuration</i>	<i>LM5mode</i>					<i>LM3mode</i>				
	Y	U	V	eTime	dTime	Y	U	V	eTime	dTime
HE_Intra	-1.5	-6.7	-5.5	100%	101%	-1.4	-6.4	-5.2	96%	100%
LoCo_Intra	-1.3	-6.4	-4.9	101%	101%	-1.2	-6.1	-4.5	94%	101%
HE_Random_access	-0.7	-6.5	-4.5	100%	100%	-0.7	-6.2	-4.0	100%	100%
LoCo_Random_access	-0.6	-5.1	-3.0	100%	100%	-0.6	-4.7	-2.6	100%	101%
HE_Low_delay	-0.2	-2.3	-2.0	101%	100%	-0.2	-2.1	-2.1	101%	100%
LoCo_low_delay	-0.1	-1.9	-1.7	102%	99%	-0.1	-2.0	-1.7	102%	99%

Experimental results -- 2

- Consistent gain is achieved for the sequences in all resolution range

Intra configuration of LM3mode

	Intra			Intra LoCo		
	Y BD-rate	U BD-rate	Y BD-rate	U BD-rate	Y BD-rate	U BD-rate
Class A	-1.4	-7.3	-3.6	-1.1	-7.5	-2.8
Class B	-1.5	-7.6	-3.9	-1.2	-7.7	-3.5
Class C	-1.8	-7.5	-8.0	-1.7	-6.8	-7.3
Class D	-1.2	-5.0	-5.0	-1.1	-4.7	-4.4
Class E	-1.1	-4.3	-5.1	-0.5	-3.6	-4.0
All	-1.4	-6.4	-5.2	-1.2	-6.1	-4.5

Complexity analysis

❖ Operation number analysis for each chroma pixel prediction

- Operation number of LM mode
 - Smaller operation number than general UDI Mode of HEVC
 - Similar to Plane mode of AVC

Operation number of LM mode

Prediction step	Proposed LM mode		
	Mul	Add	Shift
Calculation of α and β for each block	$\sim=3 \cdot N + 6$	$\sim=6 \cdot N + 4$	$\sim=4$
Down-sample for each pixel	0	$\sim=0.5$	$\sim=0.5$
Prediction for each pixel	1	1	1
Operation for each pixel prediction	$1+3/N + 6/N^2$	$1.5+6/N + 6/N^2$	$1.5+4/N^2$

Operation number of UDI mode

Prediction step	Plane mode		
	Mul	Add	Shift
Initialisation the Main and Left reference array	~	~	~
Position calculation for each pixel	0	$1+2/N$	$1/N$
Interpolation for each pixel	2	3	1
Operation for each pixel prediction	2	$4+2/N$	$1+1/N$

Plane mode according to JM17.1 code

Prediction step	Plane mode		
	Mul	Add	Shift
Calculation of A, B and C for each block	$\sim=N + 4$	$\sim=2 \cdot N + 4$	$\sim=3$
Prediction for each pixel	$1+2/N$	$1+4/N$	1
Operation for each pixel prediction	$1+3/N + 4/N^2$	$1+6/N + 4/N^2$	$1+3/N^2$

Conclusion

- ❖ Solid coding gain (LM3mode setting)
 - 1.3%, 6.3% and 4.9% in intra configuration,
 - With 5% encoding time reduction
 - 0.6%, 5.4% and 3.3% in random access configuration,
- ❖ Operation number
 - Similar and even smaller than existing methods in HEVC Test Model and H.264/AVC
- ❖ For YUV 4:2:2 or YUV 4:4:4 sequences, the overall gains are expected to be more remarkable
- ❖ Suggestion
 - Include proposed method (LM3mode setting) as chroma intra prediction method in next version of HEVC Test Model

Supplementary data - 1

❖ Coding gain of YUV-BD-rate according to CE4 (MC interpolation for chroma) measurement

■ LM3mode

- 3.2%, Intra HE,
- 2.8%, Intra LC
- 2.2%, Random_access HE
- 1.6%, Random_access LC

■ LM5mode

- 3.3%, Intra HE,
- 3.0%, Intra LC
- 2.4%, Random_access HE
- 1.8%, Random_access LC



Thank you !