

JCTVC-L0189

**Non-SCE3: ILR enhancement with
differential coding for Refldx framework**

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Introduction

- Inter-layer reference (ILR) picture lacks sufficient high frequency information
 - Base layer picture is quantized
 - Base layer has smaller spatial resolution in the case of spatial scalability
- The enhancement layer temporal reconstructed picture has some high frequency information and can be used to enhance inter-layer reference
- ILR enhancement with weighted differential signal is proposed

ILR enhancement with differential coding

- Differential picture generation: $ILDiff_T = \text{Clip}(EL'_T - ILR_T + I_{\text{offset}})$
- The motion information is scaled from base layer with spatial scalability ratio

- uni-prediction:

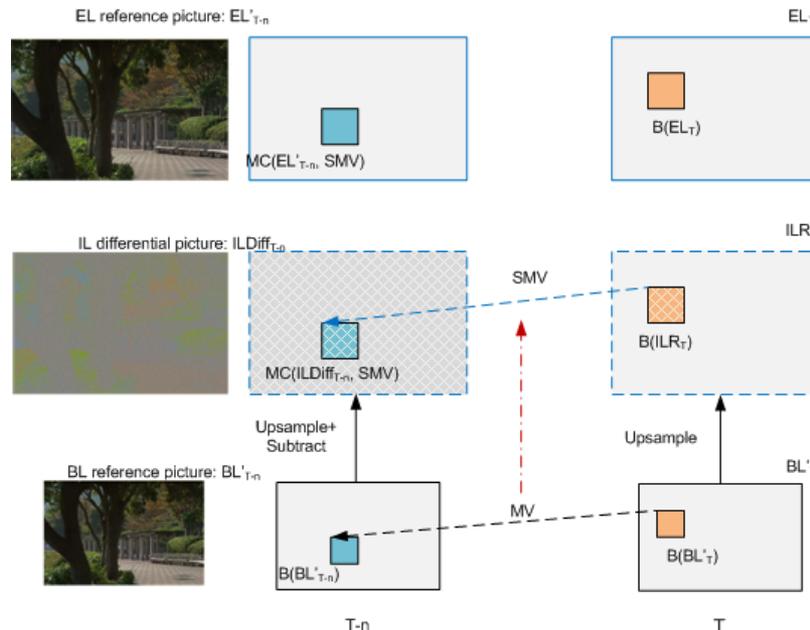
$$B(EILR_T) = \text{Clip}(B(ILR_T) + (1 - W_{\text{uni}})(ILR_{T-n}) * ((MC_{\text{DIFF}}(ILDiff_{T-n}, SMV) - I_{\text{offset}})))$$

uni-pred weight (points to $1 - W_{\text{uni}}$)
differential (points to $MC_{\text{DIFF}}(ILDiff_{T-n}, SMV) - I_{\text{offset}}$)

- bi-prediction

$$B(EILR_T) = \text{Clip}(B(ILR_T) + (1 - W_{\text{bi}})(ILR_{T-n0}, ILR_{T-n1}) * ((MC_{\text{DIFF}}(ILDiff_{T-n0}, SMV_0) + MC_{\text{DIFF}}(ILDiff_{T-n1}, SMV_1)) / 2 - I_{\text{offset}})))$$

bi-pred weight (points to $1 - W_{\text{bi}}$)
differential (points to $((MC_{\text{DIFF}}(ILDiff_{T-n0}, SMV_0) + MC_{\text{DIFF}}(ILDiff_{T-n1}, SMV_1)) / 2 - I_{\text{offset}}))$)



Weights for the differential signal

➤ Weight estimation

- Use Least Square method to estimate the weight for each reference picture for uni-prediction and each reference picture pair for bi-prediction

➤ Weights signaling

- Weight for luma: 2 bits fixed length coding for each entry of weight list at slice header
- Differential signal is added directly for chroma without weight

List	Index	
	0	1
L₀	P ₀	P ₄
L₁	P ₄	P ₈



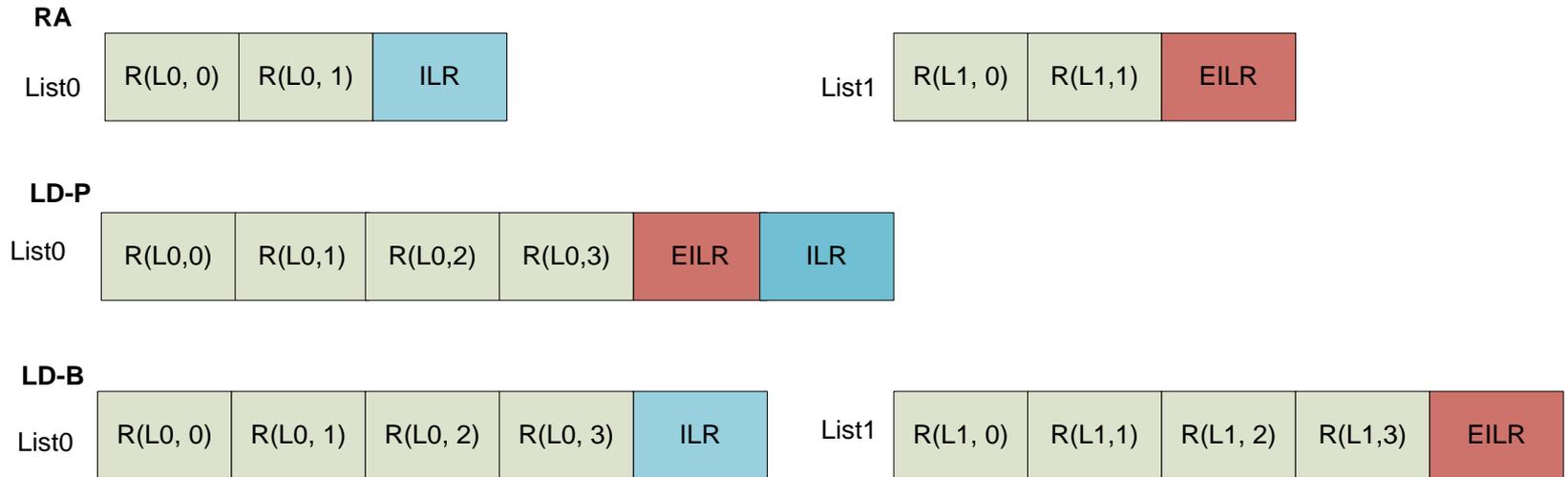
Weight set	Index			
	0	1	2	3
weight_list_uni	P ₀	P ₄	P ₈	
weight_list_bi	(P ₀ , P ₄)	(P ₀ , P ₈)	(P ₄ , P ₄)	(P ₄ , P ₈)

Reference pic lists of P₂ in RA configuration

Uni-prediction and bi-prediction weights for luma

Placement of the E-ILR picture

- In RA and LD-B, the reference picture list sizes are kept the same
- In LD-P, the reference picture list size is increased by 1



Simulation Results (SHM-1.0 ref_idx anchor)

- ILR enhancement with compressed motion from base layer

	RA HEVC 2x			RA HEVC 1.5x			RA HEVC SNR		
	Y	U	V	Y	U	V	Y	U	V
Class A	-0.8%	-3.1%	-3.0%				-1.7%	-6.1%	-6.3%
Class B	-1.1%	-3.0%	-3.4%	-1.7%	-4.5%	-5.2%	-2.1%	-6.3%	-7.6%
Overall (Test vs Ref)	-1.0%	-3.0%	-3.3%	-1.7%	-4.5%	-5.2%	-2.0%	-6.3%	-7.3%
Overall (Test vs single layer)	18.9%	29.2%	29.9%	15.4%	22.4%	24.1%	13.6%	21.5%	24.4%
EL only (Test vs Ref)	-2.2%	-4.1%	-4.4%	-5.4%	-8.1%	-8.8%	-4.1%	-8.6%	-9.6%
Enc Time[%]		118.6%			114.1%			110.1%	
Dec Time[%]		138.4%			132.7%			131.0%	

	LD-P HEVC 2x			LD-P HEVC 1.5x			LD-P HEVC SNR		
	Y	U	V	Y	U	V	Y	U	V
Class A	-1.4%	-3.6%	-3.4%				-2.1%	-5.6%	-5.7%
Class B	-2.2%	-2.8%	-2.6%	-2.9%	-5.0%	-5.0%	-3.4%	-7.3%	-8.1%
Overall (Test vs Ref)	-2.0%	-3.1%	-2.8%	-2.9%	-5.0%	-5.0%	-3.0%	-6.8%	-7.4%
Overall (Test vs single layer)	24.1%	33.5%	35.2%	19.4%	26.3%	29.1%	19.8%	24.9%	28.1%
EL only (Test vs Ref)	-3.3%	-4.3%	-4.1%	-7.2%	-9.1%	-9.1%	-5.0%	-8.9%	-9.6%
Enc Time[%]		110.1%			105.8%			104.9%	
Dec Time[%]		128.6%			124.9%			128.8%	

	LD-B HEVC 2x			LD-B HEVC 1.5x			LD-B HEVC SNR		
	Y	U	V	Y	U	V	Y	U	V
Class A	-1.0%	-3.6%	-3.4%				-1.8%	-5.8%	-6.1%
Class B	-1.6%	-3.1%	-3.3%	-2.4%	-5.6%	-5.8%	-2.4%	-6.4%	-7.5%
Overall (Test vs Ref)	-1.4%	-3.2%	-3.4%	-2.4%	-5.6%	-5.8%	-2.3%	-6.2%	-7.1%
Overall (Test vs single layer)	26.7%	34.2%	35.5%	21.8%	25.9%	28.0%	21.5%	26.0%	29.2%
EL only (Test vs Ref)	-2.6%	-4.4%	-4.5%	-6.6%	-9.5%	-9.7%	-4.0%	-8.1%	-9.0%
Enc Time[%]		128.2%			117.6%			116.9%	
Dec Time[%]		157.9%			154.6%			159.1%	

Simulation Results (SHM-1.0 ref_idx anchor)

- ILR enhancement with uncompressed motion from base layer

	RA HEVC 2x			RA HEVC 1.5x			RA HEVC SNR		
	Y	U	V	Y	U	V	Y	U	V
Class A	-2.5%	-8.0%	-7.3%				-2.8%	-9.7%	-9.8%
Class B	-1.8%	-4.7%	-5.1%	-2.6%	-6.3%	-7.0%	-2.7%	-7.7%	-9.0%
Overall (Test vs Ref)	-2.0%	-5.6%	-5.7%	-2.6%	-6.3%	-7.0%	-2.7%	-8.2%	-9.2%
Overall (Test vs single layer)	17.7%	25.6%	26.5%	14.3%	20.2%	21.7%	12.7%	18.8%	21.7%
EL only (Test vs Ref)	-4.3%	-7.8%	-7.9%	-7.8%	-11.4%	-12.1%	-5.5%	-11.2%	-12.3%
Enc Time[%]		113.3%			108.1%			102.3%	
Dec Time[%]		135.8%			130.9%			131.1%	

	LD-P HEVC 2x			LD-P HEVC 1.5x			LD-P HEVC SNR		
	Y	U	V	Y	U	V	Y	U	V
Class A	-3.4%	-8.3%	-7.6%				-3.8%	-9.4%	-9.5%
Class B	-3.1%	-4.3%	-3.9%	-3.9%	-6.8%	-7.0%	-4.2%	-8.7%	-9.7%
Overall (Test vs Ref)	-3.2%	-5.5%	-5.0%	-3.9%	-6.8%	-7.0%	-4.1%	-8.9%	-9.7%
Overall (Test vs single layer)	22.6%	30.1%	32.1%	18.1%	23.9%	26.5%	18.5%	22.0%	24.9%
EL only (Test vs Ref)	-5.6%	-7.7%	-7.2%	-9.7%	-12.3%	-12.4%	-6.7%	-11.7%	-12.5%
Enc Time[%]		108.7%			108.0%			110.0%	
Dec Time[%]		130.0%			129.2%			137.4%	

	LD-B HEVC 2x			LD-B HEVC 1.5x			LD-B HEVC SNR		
	Y	U	V	Y	U	V	Y	U	V
Class A	-2.9%	-8.4%	-7.7%				-3.1%	-9.1%	-9.3%
Class B	-2.4%	-4.6%	-5.0%	-3.4%	-7.2%	-7.5%	-3.0%	-7.4%	-8.7%
Overall (Test vs Ref)	-2.5%	-5.7%	-5.7%	-3.4%	-7.2%	-7.5%	-3.0%	-7.9%	-8.9%
Overall (Test vs single layer)	25.3%	30.7%	32.2%	20.6%	23.7%	25.6%	20.6%	23.7%	26.6%
EL only (Test vs Ref)	-4.8%	-7.8%	-7.8%	-8.9%	-12.5%	-12.7%	-5.4%	-10.4%	-11.4%
Enc Time[%]		124.1%			114.9%			110.7%	
Dec Time[%]		159.0%			156.5%			158.4%	

Conclusions

- ILR enhancement with differential coding gives substantial performance improvements

	Compressed BL motion			Uncompressed BL motion		
	Y	U	V	Y	U	V
RA	-1.6%	-4.6%	-5.2%	-2.5%	-6.7%	-7.3%
LDP	-2.6%	-5.0%	-5.1%	-3.7%	-7.1%	-7.2%
LDB	-2.0%	-5.0%	-5.4%	-3.0%	-6.9%	-7.4%

- Average complexity

	Aver Complexity				
	8b/8b	64b/256b	64b/512b	Mults	Adds
RA	133%	139%	141%	124%	130%
LD-P	137%	141%	143%	128%	136%
LD-B	142%	148%	151%	131%	138%

Thanks Canon for cross checking (JCTVC-M0362)!