JCTVC-N0204
ILR enhancement with differential coding for SHVC reference index framework

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invention | collaboration | contribution

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

- The motion information is scaled from base layer with spatial scalability ratio
  - uni-prediction:

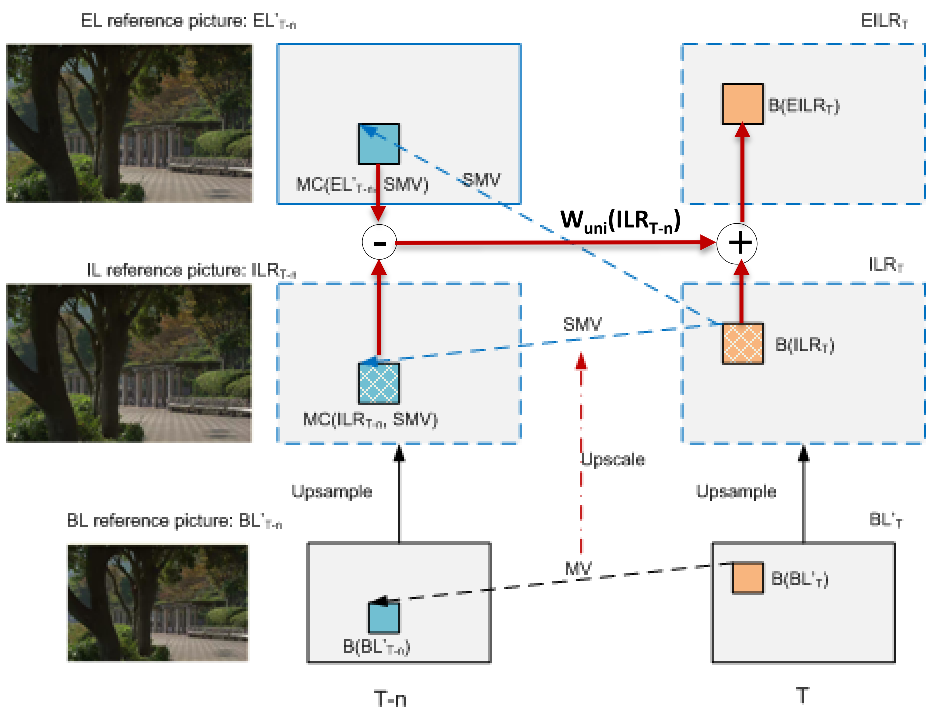
uni-pred weight — differential

$$B(EILR_T) = Clip(B(ILR_T) + (1-W_{uni}(ILR_{T-n})) * (MC(EL'_{T-n}, SMV) - MC(ILR_{T-n}, SMV)))$$

  - bi-prediction

bi-pred weight — differential

$$B(EILR_T)= Clip(B(ILR_T)+(1-W_{bi}(ILR_{T-n0}, ILR_{T-n1}))* ((MC(EL'_{T-n0}, SMV_0)+MC(EL'_{T-n1}, SMV_1))/2 - (MC(ILR_{T-n0}, SMV_0)+MC(ILR_{T-n1}, SMV_1))/2))$$



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
L_0	P_0	P_4
L_1	P_4	P_8

Reference pic lists of P_2 in RA configuration

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)

Uni-prediction and bi-prediction weights for luma

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Placement of the E-ILR picture

- Setting 1: add E-ILR as second inter-layer reference 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

RA

List0	R(L0, 0)	R(L0, 1)	ILR
List1	R(L1, 0)	R(L1,1)	E-ILR

LD-P

List0	R(L0,0)	R(L0,1)	R(L0,2)	R(L0,3)	E-ILR	ILR

LD-B

List0	R(L0, 0)	R(L0, 1)	R(L0, 2)	R(L0, 3)	ILR
List1	R(L1, 0)	R(L1,1)	R(L1, 2)	R(L1,3)	E-ILR

- Setting 2: combine ILR and E-ILR as one inter-layer reference picture
  - ILR' could be ILR, picture-based E-ILR, or block-based E-ILR

RA

List0	R(L0, 0)	R(L0, 1)	ILR'
List1	R(L1, 0)	R(L1,1)	ILR'

LD-P

List0	R(L0,0)	R(L0,1)	R(L0,2)	R(L0,3)	ILR'

LD-B

List0	R(L0, 0)	R(L0, 1)	R(L0, 2)	R(L0, 3)	ILR'
List1	R(L1, 0)	R(L1,1)	R(L1, 2)	R(L1,3)	ILR'

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Simulation Results (SHM-2.0 RefIdx anchor)

- Simulation results with 4 test cases
  - Setting for 4 test cases:
    - Bilinear is used for motion compensation for ILR enhancement
    - The scaling factor for fixed-point weight representation is 4, the weight is only applied to luma component
  - Test case 1: uncompressed motion from BL is used for ILR enhancement, and 2 inter-layer reference pictures (ILR, E-ILR)
  - Test case 2: 8x8 sized compressed motion from BL is used for ILR enhancement, and 2 inter-layer reference pictures (ILR, E-ILR)
  - Test case 3: 16x16 sized compressed motion from BL is used for ILR enhancement, and 2 inter-layer reference pictures (ILR, E-ILR)
  - Test case 4: 16x16 sized compressed motion from BL is used for ILR enhancement, and 1 inter-layer reference picture (ILR, picture-based E-ILR, or 64x64 block-based E-ILR)

Index	Test cases	Coding configurations	Aver Results		
			Y	U	V
1	Uncompressed motion	RA	-2.3%	-6.6%	-7.4%
		LD-B	-2.9%	-7.0%	-7.6%
		LD-P	-3.6%	-6.9%	-7.3%
		Average	-2.9%	-6.8%	-7.4%
2	8x8 Compressed motion	RA	-2.1%	-6.0%	-6.9%
		LD-B	-2.6%	-6.4%	-7.0%
		LD-P	-3.2%	-6.2%	-6.5%
		Average	-2.6%	-6.2%	-6.8%
3	16x16 Compressed motion	RA	-1.5%	-4.5%	-5.4%
		LD-B	-2.0%	-5.1%	-5.6%
		LD-P	-2.5%	-4.9%	-5.1%
		Average	-2.0%	-4.8%	-5.4%
4	16x16 Compressed motion + one ILR	RA	-1.2%	-4.7%	-5.9%
		LD-B	-1.6%	-4.4%	-5.1%
		LD-P	-1.8%	-3.2%	-3.7%
		Average	-1.5%	-4.1%	-4.9%

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Simulation Results (SHM-2.0 RefIdx anchor)

- Detailed BD results of test case 1 (uncompressed motion) , the following results are reported: RA -2.3%, LDB -2.9%, LDP -3.6% for luma component on average

	RA HEVC 2x			RA HEVC 1.5x			RA HEVC SNR		
	Y	U	V	Y	U	V	Y	U	V
Class A	-2.3%	-7.6%	-7.2%				-2.6%	-9.0%	-9.5%
Class B	-1.8%	-4.5%	-5.1%	-2.4%	-6.0%	-7.0%	-2.6%	-8.0%	-9.7%
Overall (Test vs Ref)	-2.0%	-5.4%	-5.7%	-2.4%	-6.0%	-7.0%	-2.6%	-8.3%	-9.6%
Overall (Test vs single layer)	16.9%	26.1%	24.4%	13.4%	21.2%	20.3%	11.5%	20.8%	20.8%
Overall (Ref vs single layer)	19.2%	33.3%	32.0%	16.2%	28.8%	29.1%	14.4%	32.1%	34.1%
EL only (Test vs Ref)	-4.0%	-7.4%	-7.7%	-7.0%	-10.6%	-11.5%	-4.9%	-10.9%	-12.4%
Enc Time[%]	110.4%			104.5%			111.9%		

	LD-B HEVC 2x			LD-B HEVC 1.5x			LD-B HEVC SNR		
	Y	U	V	Y	U	V	Y	U	V
Class A	-2.8%	-8.4%	-7.8%				-3.0%	-9.1%	-9.6%
Class B	-2.4%	-4.7%	-4.9%	-3.3%	-7.1%	-7.7%	-2.9%	-7.8%	-9.4%
Overall (Test vs Ref)	-2.5%	-5.8%	-5.8%	-3.3%	-7.1%	-7.7%	-3.0%	-8.2%	-9.5%
Overall (Test vs single layer)	25.3%	30.9%	31.6%	20.6%	23.8%	25.6%	20.7%	23.4%	25.8%
Overall (Ref vs single layer)	28.5%	39.0%	39.7%	24.8%	33.0%	35.9%	24.3%	34.7%	39.5%
EL only (Test vs Ref)	-4.7%	-7.9%	-7.9%	-8.8%	-12.2%	-12.8%	-5.3%	-10.7%	-12.0%
Enc Time[%]	103.8%			97.4%			102.3%		

	LD-P HEVC 2x			LD-P HEVC 1.5x			LD-P HEVC SNR		
	Y	U	V	Y	U	V	Y	U	V
Class A	-3.3%	-8.2%	-7.4%				-3.6%	-9.2%	-9.4%
Class B	-3.0%	-4.2%	-4.2%	-3.8%	-6.7%	-6.7%	-4.0%	-8.7%	-10.1%
Overall (Test vs Ref)	-3.1%	-5.3%	-5.1%	-3.8%	-6.7%	-6.7%	-3.9%	-8.8%	-9.9%
Overall (Test vs single layer)	22.7%	30.6%	32.0%	18.2%	24.1%	26.7%	18.7%	22.1%	24.7%
Overall (Ref vs single layer)	26.6%	38.0%	39.1%	22.8%	32.8%	35.6%	23.4%	34.6%	39.4%
EL only (Test vs Ref)	-5.5%	-7.6%	-7.4%	-9.6%	-12.2%	-12.2%	-6.5%	-11.6%	-12.7%
Enc Time[%]	101.4%			103.2%			101.4%		

Conclusions

- ILR enhancement with differential coding gives substantial performance improvements

	Compressed BL motion			Uncompressed BL motion		
	Y	U	V	Y	U	V
RA	-1.5%	-4.5%	-5.4%	-2.3%	-6.6%	-7.4%
LD-B	-2.0%	-5.1%	-5.6%	-2.9%	-7.0%	-7.6%
LD-P	-2.5%	-4.9%	-5.1%	-3.6%	-6.9%	-7.3%

- Propose to setup CE for ILR enhancement technology

Thanks Canon for cross checking (JCTVC-N0277)!

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