JCTVC-F326

AHG18: Explicit Weighted Prediction with simple WP parameter estimation

Akiyuki Tanizawa
Takeshi Chujoh
Tomoo Yamakage

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Overall Summary

- AHG18: Weighted Prediction in HEVC
  - Provide HM3.0 S/W with AVC-like WP
  - Provide test sequences for black/white fade
- Proposal:
  - 1-pass encoding method with Simple WP parameter estimation based on alpha-blending model
- Results:
  - Report experimental results on black-fade and white-fade sequences
  - Report experimental results using 1-frame delayed WP parameter for real-time applications
  - Report additional results on cross-fade sequences
- Cross-check:
  - Checked by Technicolor (JCTVC-F457)

WP principle

- **For uni-prediction**

  $pred = ((predL_0 \times W_0 + shift/2) >> shift) + O_0$

- **For bi-prediction** (high accuracy weighted bi-pred)

  $pred=((predL_0 \times W_0 + predL_1 \times W_1 + \mathbf{hab\_shift}) >> (\mathbf{hab\_shift}+1)) + ((O_0+O_1+1)>>1)$

  where hab_shift is a shift value including bit shift used for high accuracy bi-prediction. A rounding operation for bi-prediction is performed once at the last stage in motion compensation.

- Several WP modes:
  - Default: default HEVC uni or bi-prediction.
  - **Explicit**: weighting and offset factors transmitted explicitly in the slice header.
  - Implicit: weighting factors for bi prediction are derived from the distance of the current POC with the POC of the ref. pictures (B_SLICE only):

Simple WP parameter estimation

- **α -Blending model**

  $Y'(t) = \alpha(t)*Y(t)+(1-\alpha(t))*C$

  where $Y(t)$ is the original picture at time t and $Y'(t)$ is the fading picture. C is a tagert pixel value (such as 16 for black fade and 235 for white fade etc.) and $\alpha(t)$ means alpha-blending parameter.

- Weighting factor and offset factor:

  $Y'(t) = \underline{\alpha(t)/\alpha(t-1)}*Y(t-1)+\underline{(1-\alpha(t)/\alpha(t-1))*C},$

- Introduce AC and DC components of $Y(t)$:

$$W_0 = \frac{\sum_N |AC(Y'(t))|}{\sum_N |AC(Y'(t-1))|} = \frac{\alpha(t)}{\alpha(t-1)},$$

$$O_0 = DC(Y'(t)) - W_0 \times DC(Y'(t-1)) = dc(t) - W_0 \times dc(t-1)$$

1-pass encoding method

- **Simple WP parameter estimation for HM3.0**

1. Calculate AC/DC values for current original picture and store them in the local memory corresponding to POC number.
2. Compute the weighting factor w_0 using the calculated AC value and the stored AC value corresponding to POC number.
3. Compute the offset factor o_0 using the weighting factor w_0, the calculated DC value and the stored DC value corresponding to POC number.
4. Compute SAD values between current picture and reference picture with/without WP parameters.
5. Select whether WP is used or not based on SAD values.
6. Encode the current picture with/without WP method.

1-pass encoding method for real-time application

- **1-frame delayed WP parameter estimation**

1. **Encode the current picture with/without WP method using WP parameter calculated in the previous picture.**
2. Calculate AC/DC values for current original picture and store them in the local memory corresponding to POC number.
3. Compute the weighting factor w_0 using the calculated AC value and the stored AC value corresponding to refIdx.
4. Compute the offset factor o_0 using the weighting factor w_0, the calculated DC value and the stored DC value corresponding to refIdx.
5. Compute SAD values between current picture and reference picture with/without WP parameters.
6. Select whether WP is used or not based on SAD values.

Experimental results for ideal WP parameters

Black-fade sequences

	Random Access HE			Random Access LC		
	Y	U	V	Y	U	V
Class A	-18.6	-21.2	-21.9	-20.1	-18.5	-18.9
Class B	-19.7	-20.1	-20.2	-21.2	-17.7	-21.7
Class C	-16.2	-16.9	-18.0	-18.8	-16.9	-19.6
Class D	-15.4	-15.3	-15.7	-17.9	-14.6	-17.8
Class E						
Overall	**-17.6**	**-18.4**	**-19.0**	**-19.6**	**-16.9**	**-19.6**
Enc Time[%]	120%			125%		
Dec Time[%]	98%			98%		

	Low delay B HE			Low delay B LC		
	Y	U	V	Y	U	V
Class A						
Class B	-25.6	-19.5	-18.9	-32.3	-39.1	-34.2
Class C	-14.5	-13.8	-14.9	-19.9	-29.4	-27.5
Class D	-13.7	-14.6	-15.8	-18.2	-25.3	-23.9
Class E	-40.4	-16.9	-21.7	-46.9	-34.5	-39.2
Overall	**-22.6**	**-16.4**	**-17.7**	**-28.4**	**-32.4**	**-30.9**
Enc Time[%]	115%			123%		
Dec Time[%]	83%			80%		

	Low delay P HE			Low delay P LC		
	Y	U	V	Y	U	V
Class A						
Class B	-24.7	-14.6	-10.6	-29.9	-33.9	-25.5
Class C	-15.0	-13.2	-14.5	-20.2	-27.3	-25.4
Class D	-16.5	-16.3	-17.4	-20.4	-24.4	-22.5
Class E	-41.5	-18.5	-20.0	-47.2	-29.5	-33.5
Overall	**-23.4**	**-15.4**	**-15.1**	**-28.3**	**-29.1**	**-26.2**
Enc Time[%]	101%			106%		
Dec Time[%]	83%			79%		

White-fade sequences

	Random Access HE			Random Access LC		
	Y	U	V	Y	U	V
Class A	-20.6	-23.9	-25.1	-22.1	-21.9	-22.7
Class B	-21.4	-23.8	-23.4	-23.8	-22.5	-26.1
Class C	-16.3	-18.3	-19.1	-19.1	-19.2	-22.0
Class D	-14.6	-14.9	-15.0	-17.6	-15.9	-20.2
Class E						
Overall	**-18.4**	**-20.4**	**-20.8**	**-20.9**	**-20.0**	**-22.9**
Enc Time[%]	118%			122%		
Dec Time[%]	102%			100%		

	Low delay B HE			Low delay B LC		
	Y	U	V	Y	U	V
Class A						
Class B	-24.9	-20.3	-19.9	-33.8	-41.7	-38.5
Class C	-14.0	-14.5	-15.2	-20.4	-32.2	-29.4
Class D	-10.6	-15.2	-15.8	-16.3	-27.7	-25.3
Class E	-36.1	-19.2	-19.9	-45.1	-37.2	-42.4
Overall	**-20.7**	**-17.4**	**-17.7**	**-28.2**	**-35.0**	**-33.7**
Enc Time[%]	115%			121%		
Dec Time[%]	86%			84%		

	Low delay P HE			Low delay P LC		
	Y	U	V	Y	U	V
Class A						
Class B	-24.5	-17.3	-13.7	-31.8	-35.3	-30.0
Class C	-14.9	-14.5	-15.4	-20.6	-29.5	-27.4
Class D	-14.2	-15.7	-15.8	-19.2	-26.7	-25.3
Class E	-37.4	-15.4	-19.8	-44.3	-31.2	-34.4
Overall	**-21.9**	**-15.8**	**-15.8**	**-28.2**	**-30.9**	**-29.0**
Enc Time[%]	100%			105%		
Dec Time[%]	86%			84%		

Experimental results for 1-pass WP parameter estimation

Black-fade sequences

	Random Access HE			Random Access LC		
	Y	U	V	Y	U	V
Class A	-17.5	-20.7	-21.0	-18.4	-14.1	-13.6
Class B	-19.6	-19.8	-19.9	-19.9	-8.7	-18.3
Class C	-14.9	-14.7	-15.1	-16.2	-11.6	-13.8
Class D	-15.0	-13.8	-13.8	-16.5	-10.6	-13.2
Class E						
Overall	**-16.9**	**-17.4**	**-17.6**	**-17.9**	**-11.1**	**-14.9**
Enc Time[%]	121%			127%		
Dec Time[%]	100%			101%		

	Low delay B HE			Low delay B LC		
	Y	U	V	Y	U	V
Class A						
Class B	-25.8	-21.5	-21.3	-31.6	-28.7	-36.7
Class C	-13.4	-12.3	-12.4	-18.0	-26.1	-25.2
Class D	-13.2	-14.6	-14.0	-17.5	-23.6	-25.3
Class E	-42.7	-29.0	-28.7	-48.1	-38.5	-46.0
Overall	**-22.7**	**-18.9**	**-18.6**	**-27.7**	**-28.6**	**-32.7**
Enc Time[%]	116%			124%		
Dec Time[%]	83%			82%		

	Low delay P HE			Low delay P LC		
	Y	U	V	Y	U	V
Class A						
Class B	-25.4	-19.4	-18.1	-30.1	-28.3	-31.2
Class C	-14.3	-11.8	-12.7	-18.7	-25.5	-23.8
Class D	-16.4	-16.7	-16.4	-20.0	-25.0	-26.8
Class E	-44.2	-31.1	-29.0	-48.4	-37.8	-35.8
Overall	**-23.9**	**-19.0**	**-18.4**	**-28.1**	**-28.5**	**-29.1**
Enc Time[%]	100%			108%		
Dec Time[%]	82%			81%		

White-fade sequences

	Random Access HE			Random Access LC		
	Y	U	V	Y	U	V
Class A	-22.2	-25.6	-26.0	-22.5	-16.6	-17.7
Class B	-23.4	-25.4	-24.7	-23.7	-15.1	-22.1
Class C	-16.9	-17.6	-18.3	-18.6	-14.7	-17.1
Class D	-16.1	-15.3	-14.7	-17.8	-12.6	-16.6
Class E						
Overall	**-19.9**	**-21.2**	**-21.1**	**-20.8**	**-14.8**	**-18.6**
Enc Time[%]	117%			122%		
Dec Time[%]	98%			102%		

	Low delay B HE			Low delay B LC		
	Y	U	V	Y	U	V
Class A						
Class B	-28.7	-24.5	-23.9	-35.6	-32.2	-39.1
Class C	-15.4	-13.9	-14.8	-20.8	-28.4	-27.2
Class D	-12.8	-16.1	-14.7	-18.0	-24.9	-26.7
Class E	-44.0	-32.9	-29.8	-50.7	-40.4	-47.6
Overall	**-24.3**	**-21.3**	**-20.4**	**-30.3**	**-31.0**	**-34.6**
Enc Time[%]	111%			119%		
Dec Time[%]	82%			82%		

	Low delay P HE			Low delay P LC		
	Y	U	V	Y	U	V
Class A						
Class B	-28.1	-22.7	-21.1	-34.5	-30.4	-33.5
Class C	-16.2	-13.7	-15.1	-21.7	-27.2	-26.4
Class D	-16.5	-16.6	-16.3	-21.2	-27.0	-28.4
Class E	-45.1	-32.8	-31.9	-51.7	-39.6	-39.8
Overall	**-25.4**	**-20.8**	**-20.4**	**-31.2**	**-30.5**	**-31.6**
Enc Time[%]	96%			101%		
Dec Time[%]	82%			81%		

Experimental results for 1-frame delayed WP param. estimation

Black-fade sequences

	Random Access HE			Random Access LC		
	Y	U	V	Y	U	V
Class A						
Class B						
Class C						
Class D						
Class E						
Overall						
Enc Time[%]						
Dec Time[%]						

	Low delay B HE			Low delay B LC		
	Y	U	V	Y	U	V
Class A						
Class B	-23.7	-19.5	-18.6	-28.5	-28.0	-34.6
Class C	-12.5	-11.2	-11.4	-17.0	-25.7	-23.7
Class D	-12.2	-13.2	-12.6	-16.0	-21.9	-23.6
Class E	-39.5	-25.7	-24.4	-45.1	-36.0	-44.6
Overall	**-21.0**	**-17.0**	**-16.4**	**-25.6**	**-27.4**	**-31.0**
Enc Time[%]	117%			125%		
Dec Time[%]	84%			83%		

	Low delay P HE			Low delay P LC		
	Y	U	V	Y	U	V
Class A						
Class B	-23.2	-17.1	-14.9	-26.9	-26.9	-28.9
Class C	-13.3	-11.5	-11.5	-17.5	-24.6	-22.7
Class D	-15.2	-15.1	-15.1	-18.5	-23.8	-25.0
Class E	-41.2	-26.9	-25.7	-45.1	-33.9	-34.2
Overall	**-22.1**	**-17.1**	**-16.1**	**-25.8**	**-26.8**	**-27.3**
Enc Time[%]	102%			109%		
Dec Time[%]	84%			82%		

White-fade sequences

	Random Access HE			Random Access LC		
	Y	U	V	Y	U	V
Class A						
Class B						
Class C						
Class D						
Class E						
Overall						
Enc Time[%]						
Dec Time[%]						

	Low delay B HE			Low delay B LC		
	Y	U	V	Y	U	V
Class A						
Class B	-26.2	-21.3	-20.5	-33.0	-32.3	-37.0
Class C	-14.5	-13.2	-13.4	-20.0	-27.9	-26.3
Class D	-11.9	-14.7	-13.3	-16.8	-24.5	-24.9
Class E	-41.1	-29.8	-26.8	-48.3	-38.6	-47.1
Overall	**-22.5**	**-19.2**	**-18.1**	**-28.6**	**-30.4**	**-33.2**
Enc Time[%]	113%			121%		
Dec Time[%]	84%			83%		

	Low delay P HE			Low delay P LC		
	Y	U	V	Y	U	V
Class A						
Class B	-25.7	-19.8	-18.1	-31.6	-30.2	-31.6
Class C	-15.4	-13.0	-13.2	-20.7	-26.9	-25.2
Class D	-15.3	-15.5	-14.8	-19.9	-25.9	-26.4
Class E	-42.3	-29.1	-28.0	-48.9	-36.6	-38.2
Overall	**-23.6**	**-18.7**	**-17.9**	**-29.2**	**-29.5**	**-30.0**
Enc Time[%]	98%			104%		
Dec Time[%]	83%			82%		

Additional tests for Cross-fade sequences

- Randomly select sequences for each class and create linear cross-fade sequences using the fading tool provided by WP AHG.

Class	Cross-fade sequences	
	Source	**Destination**
Class B	BQTerrace	Kimono
	BasketballDrive	ParkScene
	Cactus	BasketballDrive
	Kimono	Cactus
	ParkScene	BQTerrace
Class C	BQMall	BasketballDrill
	BasketballDrill	RaceHorses
	PartyScene	BQMall
	RaceHorses	PartyScene
Class D	BQSquare	BasketballPass
	BasketballPass	RaceHorses
	BlowingBubbles	BQSquare
	RaceHorses	BlowingBubbles
Class E	Vidyo1	Vidyo3
	Vidyo3	Vidyo4
	Vidyo4	Vidyo1

Experimental results for cross-fade

	Random Access HE			Random Access LC		
	Y	U	V	Y	U	V
Class A						
Class B	-5.8	-5.3	-5.7	-5.7	-1.1	-4.5
Class C	-2.1	-1.9	-1.7	-2.3	-2.1	-1.8
Class D	-3.2	0.1	-2.3	-3.3	1.4	-1.4
Class E						
Overall	**-3.8**	**-2.6**	**-3.4**	**-3.9**	**-0.6**	**-2.7**
Enc Time[%]	106%			114%		
Dec Time[%]	88%			95%		

	Low delay B HE			Low delay B LC		
	Y	U	V	Y	U	V
Class A						
Class B	-4.9	-3.8	-3.6	-7.5	-7.9	-10.3
Class C	-0.7	-1.3	-0.8	-1.9	-5.7	-4.7
Class D	-0.9	-0.4	-2.5	-2.6	-6.2	-8.2
Class E	-2.6	-1.8	-1.4	-4.9	-7.0	-8.8
Overall	**-2.4**	**-2.0**	**-2.2**	**-4.4**	**-6.8**	**-8.1**
Enc Time[%]	103%			111%		
Dec Time[%]	84%			92%		

	Low delay P HE			Low delay P LC		
	Y	U	V	Y	U	V
Class A						
Class B	-4.4	-3.4	-3.3	-7.0	-6.8	-8.1
Class C	-1.1	-1.4	-1.3	-2.4	-6.2	-4.8
Class D	-2.1	-1.1	-4.0	-4.0	-7.2	-10.0
Class E	-3.4	-2.3	-2.7	-5.4	-5.8	-7.3
Overall	**-2.8**	**-2.1**	**-2.9**	**-4.8**	**-6.6**	**-7.6**
Enc Time[%]	101%			111%		
Dec Time[%]	83%			92%		

Summary of experimental results

- **For black-fade sequences**

	RA-HE	RA-LC	LDB-HE	LDB-LC	LDP-HE	LDP-LC
Ideal WP param	-17.6%	-19.6%	-22.6%	-28.4%	-23.4%	-28.3%
1-pass WP	-16.9%	-17.9%	-22.7%	-27.7%	-23.9%	-28.1%
1-pass WP LD	N/A	N/A	-21.0%	-25.6%	-22.1%	-25.8%

- **For white-fade sequences**

	RA-HE	RA-LC	LDB-HE	LDB-LC	LDP-HE	LDP-LC
Ideal WP param	-18.4%	-20.9%	-20.7%	-28.2%	-21.9%	-28.2%
1-pass WP	-19.9%	-20.8%	-24.3%	-30.3%	-25.4%	-31.2%
1-pass WP LD	N/A	N/A	-22.5%	-28.6%	-23.6%	-29.2%

- **For cross-fade sequences**

	RA-HE	RA-LC	LDB-HE	LDB-LC	LDP-HE	LDP-LC
1-pass WP	-3.8%	-3.9%	-2.4%	-4.4%	-2.8%	-4.8%

- **For common test sequences**

	RA-HE	RA-LC	LDB-HE	LDB-LC	LDP-HE	LDP-LC
1-pass WP	0.9%	1.2%	0.9%	0.9%	0.6%	0.6%

- WP method in HEVC is effective for fading-sequences and it does not have a big impact for regular sequences

Conclusion

- Proposal:
  - 1-pass encoding algorithm with **Simple WP parameter estimation** based on alpha-blending model
- Experimental Results:
  - For Black-fade and White-fade sequences
    - Average 17% **to** 31% gain (up to 60%)
  - For cross-fade sequences
    - Average 2% **to** 5% gain (up to 16%)
  - For regular sequences
    - Average 1% loss (no big impact)
- Suggestion;
  - WP method is integrated to next version of HM.

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