Reference Pictures
for Low Delay Settings

Chong Soon Lim
Sue Mon Thet Naing
Viktor Wahadaniah

Panasonic Corporation

Reference Pictures Used in HM-3.0

HM-3.0

- Using 4 reference pictures
- Selecting the nearest reference pictures for both List0 and List1.

Reference Pictures used in HM-3

|		
POC 0	[L0]	[L1]
POC 1	[L0 0]	[L1 0]
POC 2	[L0 1 0]	[L1 1 0]
POC 3	[L0 2 1 0]	[L1 2 1 0]
POC 4	[L0 3 2 1 0]	[L1 3 2 1 0]
POC 5	[L0 4 3 2 1]	[L1 4 3 2 1]
POC 6	[L0 5 4 3 2]	[L1 5 4 3 2]
POC 7	[L0 6 5 4 3]	[L1 6 5 4 3]
POC 8	[L0 7 6 5 4]	[L1 7 6 5 4]
POC 9	[L0 8 7 6 5]	[L1 8 7 6 5]
POC 10	[L0 9 8 7 6]	[L1 9 8 7 6]
POC 11	[L0 10 9 8 7]	[L1 10 9 8 7]
POC 12	[L0 11 10 9 8]	[L1 11 10 9 8]
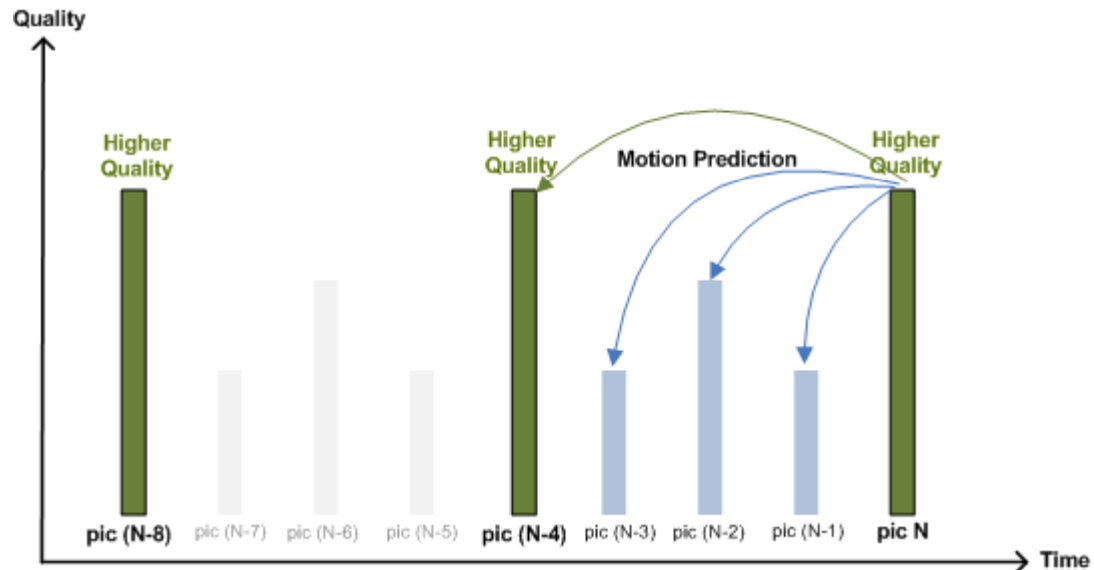
Reference Pictures Used in JCTVC-F433

JCTVC-F433

- Using 4 reference pictures

- Selecting only the two nearest reference pictures and two of the high quality reference pictures.

Reference Pictures used in proposal

| POC	L0	L1
POC 0	[L0]	[L1]
POC 1	[L0 0]	[L1 0]
POC 2	[L0 1 0]	[L1 1 0]
POC 3	[L0 2 1 0]	[L1 2 1 0]
POC 4	[L0 3 2 1 0]	[L1 3 2 1 0]
POC 5	[L0 4 3 2 0]	[L1 4 3 2 0]
POC 6	[L0 5 4 3 0]	[L1 5 4 3 0]
POC 7	[L0 6 5 4 0]	[L1 6 5 4 0]
POC 8	[L0 7 6 4 0]	[L1 7 6 4 0]
POC 9	[L0 8 7 4 0]	[L1 8 7 4 0]
POC 10	[L0 9 8 4 0]	[L1 9 8 4 0]
POC 11	[L0 10 9 8 4]	[L1 10 9 8 4]
POC 12	[L0 11 10 8 4]	[L1 11 10 8 4]
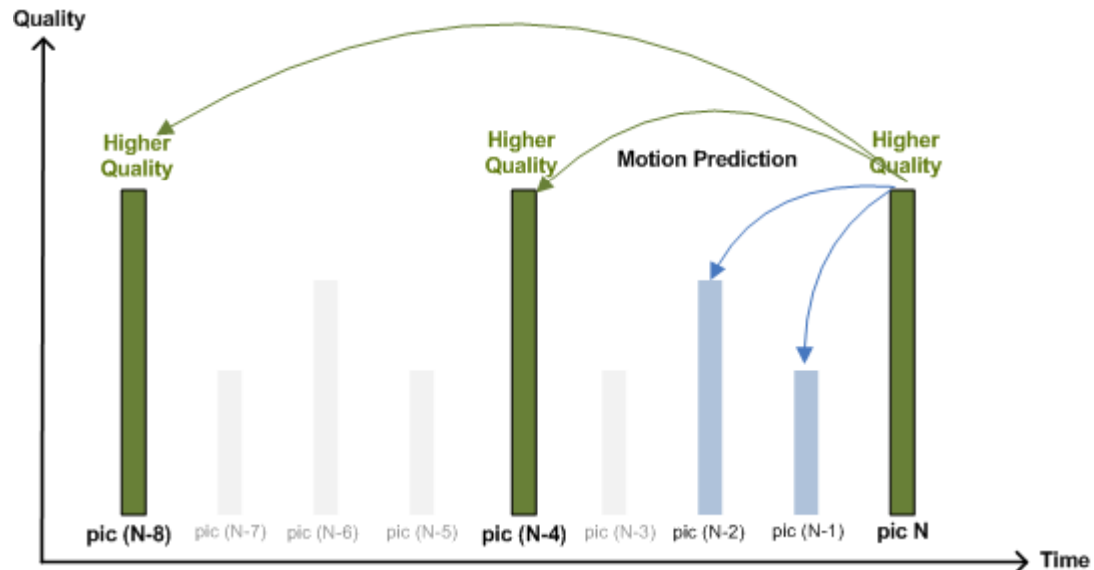
Reference Pictures Memory Management
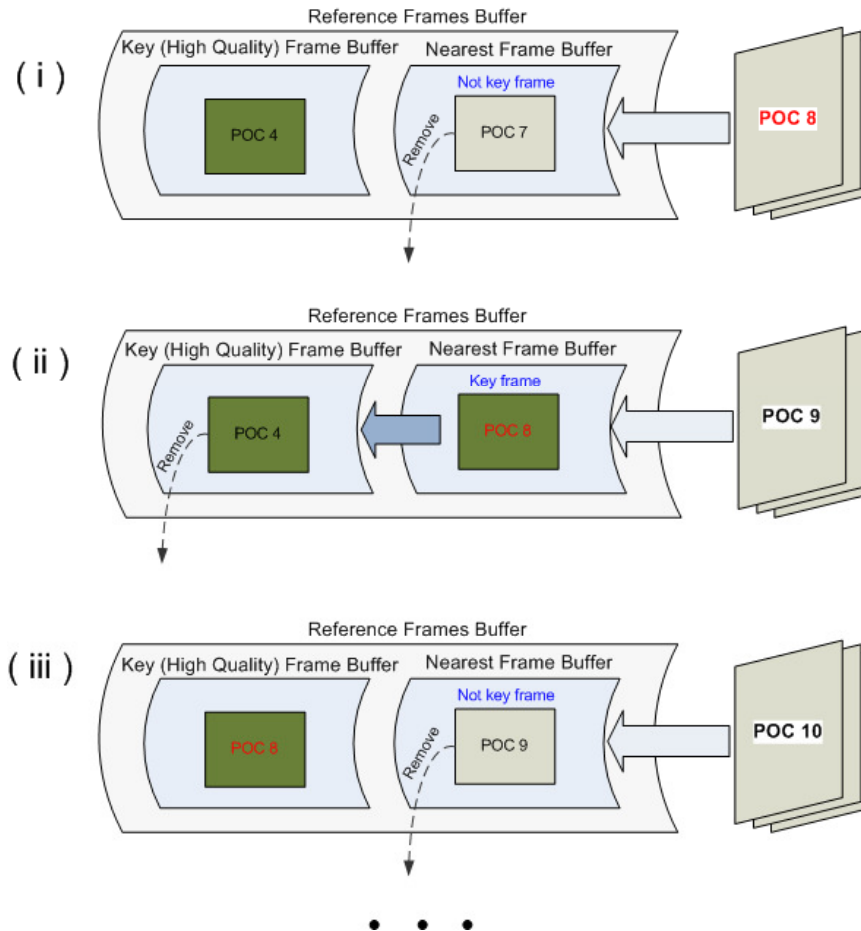
JCTVC-F433

4 reference pictures

▪Key frames are kept slightly longer than the non-key reference frames in reference frame buffer.

▪When all buffers are full and another key frame enters the key frame buffer, the oldest key frame is removed from the reference frame buffer.

▪Otherwise, the oldest non-key frame is removed from the reference frame buffer based on the sliding window operation.
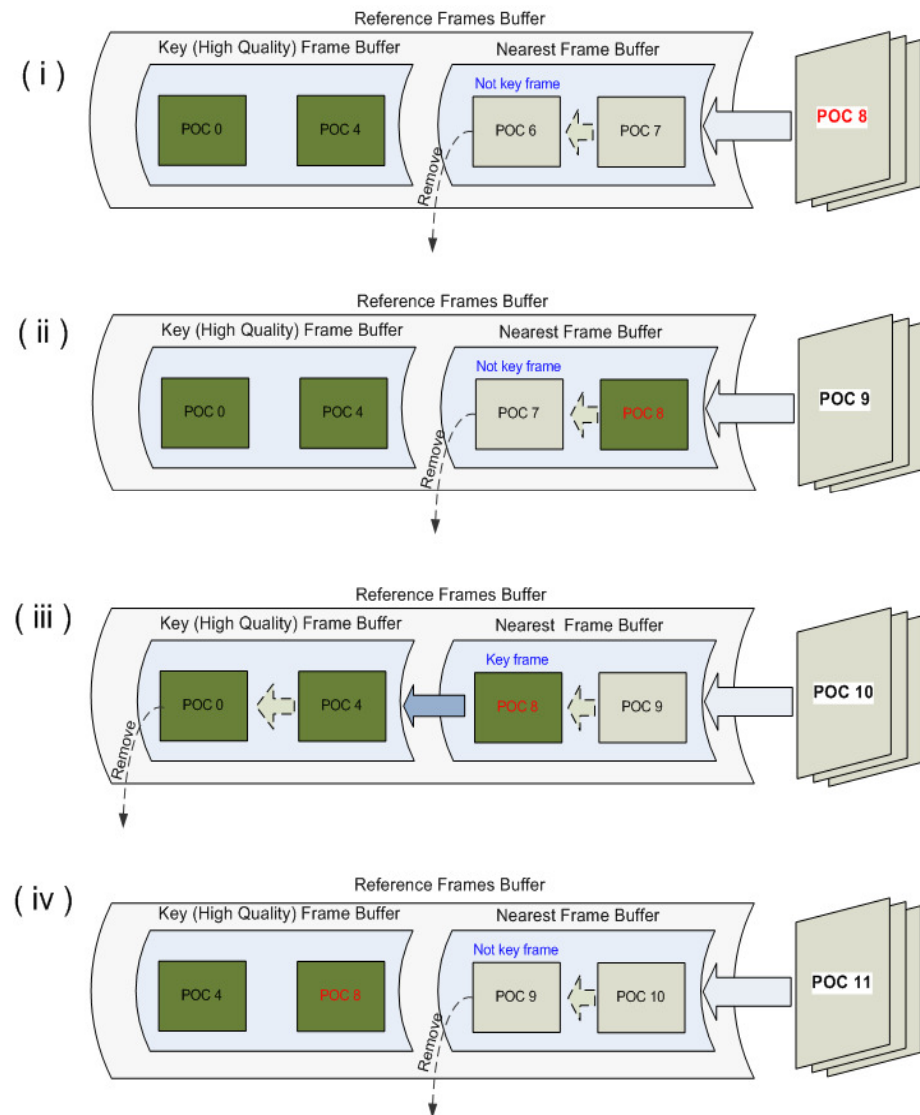
Reference Pictures Memory Management

JCTVC-F433

2 reference pictures

*Reference pictures memory management scheme for **JCTVC-F433,** using 2 reference pictures*

Experimental results for low delay settings using 4 reference pictures

Experimental Results

4 reference pictures

IBBB	Low delay B			Low delay LoCo B		
	Y BD-rate	U BD-rate	V BD-rate	Y BD-rate	U BD-rate	V BD-rate
Class A						
Class B	-1.8	-2.7	-2.8	-2.1	-3.5	-4.3
Class C	-3.1	-3.1	-3.5	-3.3	-3.9	-4.1
Class D	-3.3	-3.4	-3.9	-3.7	-5.4	-5.7
Class E	-0.7	-0.9	-1.7	-1.0	-0.9	-1.7
All	-2.3	-2.6	-3.0	-2.6	-3.6	-4.1
Enc Time[%]	104.5%			106.4%		
Dec Time[%]	97.0%			97.0%		

Average BD-rate (%) for low delay B settings

IPPP	Low delay P			Low delay LoCo P		
	Y BD-rate	U BD-rate	V BD-rate	Y BD-rate	U BD-rate	V BD-rate
Class A						
Class B	-1.7	-2.7	-2.8	-1.7	-3.1	-3.4
Class C	-2.9	-2.9	-3.3	-3.0	-3.6	-3.5
Class D	-3.4	-3.4	-3.8	-3.7	-4.8	-5.1
Class E	-0.7	-0.8	-1.0	-0.7	-0.4	-0.9
All	-2.2	-2.6	-2.9	-2.3	-3.1	-3.4
Enc Time[%]	105.8%			108.6%		
Dec Time[%]	96.7%			96.7%		

Average BD-rate (%) for low delay P settings

Experimental Results

4 reference pictures

- Anchor : HM-3.0 default configuration (NumOfReference = 4)
- Results for JCTVC-F433 using 4 references pictures

Class	Sequence	BD-rate - Low delay B			BD-rate - Low delay B (Loco)			BD-rate - Low delay P			BD-rate - Low delay P (Loco)		
		Y	U	V	Y	U	V	Y	U	V	Y	U	V
Class B	S03 Kimono	-0.3	-0.2	-0.5	-0.3	-0.8	-0.6	-0.2	-0.5	-0.3	-0.2	-0.6	-0.4
	S04 ParkScene	-1.8	-2.3	-2.2	-1.9	-3.2	-4.0	-1.5	-2.0	-2.1	-1.6	-2.5	-3.3
	S05 Cactus	-3.4	-3.8	-4.4	-3.5	-2.9	-3.7	-3.2	-4.1	-4.0	-3.1	-2.6	-3.1
	S06 BasketballDrive	-0.5	-1.4	-0.9	-0.6	-1.3	-1.0	-0.4	-1.0	-0.5	-0.4	-1.3	-0.8
	S07 BQTerrace	-3.2	-6.0	-6.1	-4.4	-9.4	-12.2	-3.2	-5.8	-7.0	-3.5	-8.4	-9.2
Class C	S08 BasketballDrill	-5.2	-4.7	-6.0	-5.4	-4.7	-5.0	-4.7	-4.0	-5.7	-4.8	-5.2	-4.7
	S09 BQMall	-0.9	-1.0	-1.1	-1.2	-2.4	-2.4	-0.9	-1.1	-1.2	-1.0	-2.2	-1.6
	S10 PartyScene	-4.8	-4.8	-4.7	-5.2	-5.9	-6.6	-4.6	-4.8	-4.6	-5.0	-5.4	-6.0
	S11 RaceHorsesC	-1.5	-1.9	-2.1	-1.6	-2.5	-2.3	-1.3	-1.7	-1.8	-1.1	-1.6	-1.8
Class D	S12 BasketballPass	-1.1	-2.0	-1.5	-1.1	-1.3	-1.0	-1.1	-1.4	-1.2	-1.1	-1.4	-1.0
	S13 BQSquare	-7.3	-6.0	-7.9	-8.8	-13.7	-14.7	-8.2	-7.7	-9.5	-9.1	-12.7	-13.4
	S14 BlowingBubbles	-3.7	-3.9	-4.6	-3.7	-4.7	-5.2	-3.4	-3.4	-3.5	-3.4	-4.3	-4.4
	S15 RaceHorsesD	-1.1	-1.6	-1.6	-1.3	-1.7	-1.8	-1.0	-0.9	-1.3	-1.0	-1.0	-1.8
ClassE	S16 Vidyo1	-0.7	-0.7	-1.1	-0.8	-1.2	-1.6	-0.3	-0.4	-0.4	-0.6	-0.5	-0.7
	S17 Vidyo3	0.0	-0.1	-1.8	-0.5	-0.3	-0.8	-0.4	-0.6	-0.1	-0.1	0.5	-0.5
	S18 Vidyo4	-1.4	-1.9	-2.3	-1.6	-1.3	-2.7	-1.5	-1.4	-2.6	-1.3	-1.1	-1.4

Per sequence BD-rate (%) for all low delay settings

Experimental results for low delay settings using 2 reference pictures

Experimental Results

2 reference pictures

IBBB	Low delay B			Low delay LoCo B		
	Y BD-rate	U BD-rate	V BD-rate	Y BD-rate	U BD-rate	V BD-rate
Class A						
Class B	-1.8	-2.8	-3.0	-2.2	-4.8	-6.1
Class C	-3.5	-3.7	-3.9	-4.3	-6.2	-6.5
Class D	-5.3	-6.2	-7.4	-6.3	-9.7	-10.9
Class E	-3.9	-3.8	-3.4	-3.2	-3.6	-2.7
All	-3.5	-4.1	-4.4	-3.9	-6.2	-6.8
Enc Time[%]	100.0%			100.8%		
Dec Time[%]	97.8%			98.1%		

Average BD-rate (%) for low delay B settings

IPPP	Low delay P			Low delay LoCo P		
	Y BD-rate	U BD-rate	V BD-rate	Y BD-rate	U BD-rate	V BD-rate
Class A						
Class B	-2.2	-3.3	-3.2	-2.1	-4.0	-4.8
Class C	-3.4	-3.5	-3.7	-3.8	-5.2	-5.7
Class D	-5.0	-5.8	-7.3	-5.5	-8.9	-10.0
Class E	-4.1	-2.8	-3.4	-3.5	-2.3	-2.3
All	-3.5	-3.9	-4.4	-3.6	-5.2	-5.9
Enc Time[%]	101.7%			101.4%		
Dec Time[%]	97.5%			97.9%		

Average BD-rate (%) for low delay P settings

Experimental Results

Panasonic
ideas for life

2 reference pictures

- Anchor : HM-3.0 default configuration with "NumOfReference = 2"
- Results for JCTVC-F433 using 2 references pictures

Class	Sequence	BD-rate - Low delay B			BD-rate - Low delay B (Loco)			BD-rate - Low delay P			BD-rate - Low delay P (Loco)		
		Y	U	V	Y	U	V	Y	U	V	Y	U	V
Class B	S03 Kimono	-0.6	-0.6	-0.6	-0.8	-2.2	-2.3	-0.6	-1.1	-0.7	-0.7	-1.5	-1.9
	S04 ParkScene	-2.4	-2.6	-2.2	-2.5	-4.3	-5.1	-2.3	-2.2	-2.6	-2.4	-4.0	-4.2
	S05 Cactus	-2.6	-1.8	-3.1	-2.2	-0.7	-3.3	-3.2	-2.4	-2.9	-2.5	-0.6	-2.9
	S06 BasketballDrive	-1.0	-1.8	-1.3	-1.4	-3.2	-2.8	-1.1	-2.2	-1.6	-1.1	-2.2	-2.3
	S07 BQTerrace	-2.3	-7.4	-8.0	-4.4	-13.7	-17.2	-3.6	-8.7	-8.3	-3.7	-11.5	-12.8
Class C	S08 BasketballDrill	-3.0	-3.0	-3.1	-3.6	-3.7	-4.2	-3.1	-2.8	-3.2	-3.1	-3.6	-4.1
	S09 BQMall	-1.6	-1.6	-1.8	-2.3	-5.7	-5.0	-1.6	-1.8	-1.5	-1.9	-3.4	-3.8
	S10 PartyScene	-8.3	-8.2	-8.5	-10.0	-13.6	-14.7	-7.5	-7.5	-8.0	-9.0	-12.0	-13.1
	S11 RaceHorsesC	-1.1	-1.9	-2.3	-1.2	-2.0	-1.9	-1.5	-1.9	-2.1	-1.2	-1.7	-1.8
Class D	S12 BasketballPass	-1.1	-1.1	-1.0	-1.2	-1.1	-1.3	-1.0	-1.1	-0.8	-1.0	-1.6	-1.0
	S13 BQSquare	-12.6	-16.1	-20.6	-16.0	-26.5	-29.2	-11.8	-15.0	-20.4	-14.2	-24.7	-28.1
	S14 BlowingBubbles	-6.0	-6.2	-6.8	-6.4	-9.4	-11.0	-5.4	-5.9	-6.7	-5.7	-8.3	-9.7
	S15 RaceHorsesD	-1.4	-1.5	-1.4	-1.4	-1.7	-2.3	-1.6	-1.2	-1.3	-1.3	-1.2	-1.3
ClassE	S16 Vidyo1	-2.4	-2.3	-1.8	-2.6	-5.4	-3.4	-2.5	-2.5	-1.3	-2.5	-3.4	-2.6
	S17 Vidyo3	-6.2	-6.3	-6.5	-5.0	-4.2	-3.8	-6.4	-4.7	-6.1	-5.5	-3.0	-4.1
	S18 Vidyo4	-3.0	-2.7	-1.9	-2.1	-1.3	-0.7	-3.5	-1.2	-2.7	-2.4	-0.7	-0.1

Per sequence BD-rate (%) for all low delay settings

Panasonic

Conclusion

➢ This contribution investigates the coding efficiency improvement of low delay settings by using a different set of reference pictures as compared to HM-3.0 anchor settings.

➢ By using 4 reference pictures,

For low delay B settings,
- **2.3%** average coding gain for high efficiency (max 7.3%),
- **2.6%** average coding gain for low complexity (max 8.8%) .

For low delay P settings,
- **2.2%** average coding gain for high efficiency (max 8.2%),
- **2.3%** average coding gain for low complexity (max 9.1%) .

➢ By using 2 reference pictures,

For low delay B settings,
- **3.5%** average coding gain for high efficiency (max 12.6%),
- **3.9%** average coding gain for low complexity (max 16.0%) .

For low delay P settings,
- **3.5%** average coding gain for high efficiency (max 11.8%),
- **3.6%** average coding gain for low complexity (max 14.2%) .

➢ We recommend JCT-VC to consider the proposed reference pictures for low delay settings.

Question ?