JCTVC-E078

Region-based adaptive interpolation filter

Shohei Matsuo, Yukihiro Bandoh,
Seishi Takamura and Hirohisa Jozawa
NTT Cyber Space Laboratories
NTT Corporation, Japan

NTT

Summary

- ❑ Conventional interpolation filter
  - – Fixed interpolation: DCT-IF, DIF, etc.
  - – Adaptive interpolation: 2D-AIF, SAIF, EAIF, etc.

- ❑ Proposed interpolation filter (JCTVC-B051, D150)
  - – Enhancement of frame-based AIF
  - – Filter coefficients are calculated on a region-by-region basis

- ❑ Simulation results (compared to HM2.0 anchor)
  - – Average coding gains:
    - HE-RA: 0.03%, HE-LD: 0.10%, LC-RA: 0.42%, LC-LD: 1.13%
  - – Computational complexity:
    - Enc-time: 125-150%, Dec-time: similar to HM2.0 ($\cong$100%)

Basic Idea

❑ SAIF: Filter coefficients are calculated on a frame-by-frame basis to minimize the prediction error energy

❑ When an original image has multiple movements or each region of the image has different characteristics (motion, texture, etc.),

  – Frame-based AIF might not be effective

❑ Proposal: Region-Based AIF (RBAIF)

  – Filter coefficients are derived on a region-by-region basis
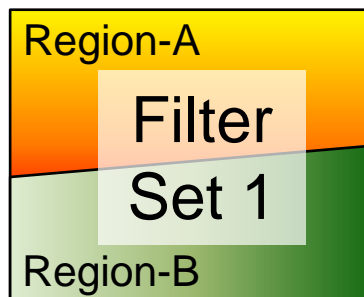
Conventional AIF
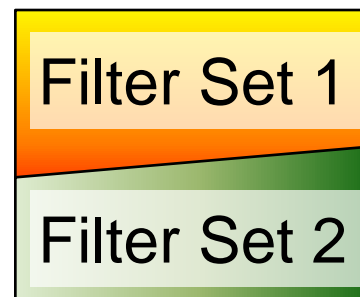
RBAIF

Definition of segmentation modes

Filter	# of regions	Method	Criteria of segmentation	
DCT-IF	1	DCT-IF 8 tap	-	
AIF	1	Frame-based AIF	-	
RBAIF-0	2	Motion speed (1)	$\alpha_x < MVx < \beta_x$	Otherwise
RBAIF-1	2	Motion speed (2)	$\alpha_y < MVy < \beta_y$	Otherwise
RBAIF-2	2	Edge	Vertical	Horizontal
RBAIF-3	2	Left/right (variable)	$x < Tx$	Otherwise
RBAIF-4	2	Top/bottom (variable)	$y < Ty$	Otherwise

Proposed RBAIF modes

Expected Effect

- ❑ Merit:
  - – Improvement of coding efficiency
    - Reducing prediction error energy in view of image locality
  - – Adaptability
    - Combined with frame-based AIFs

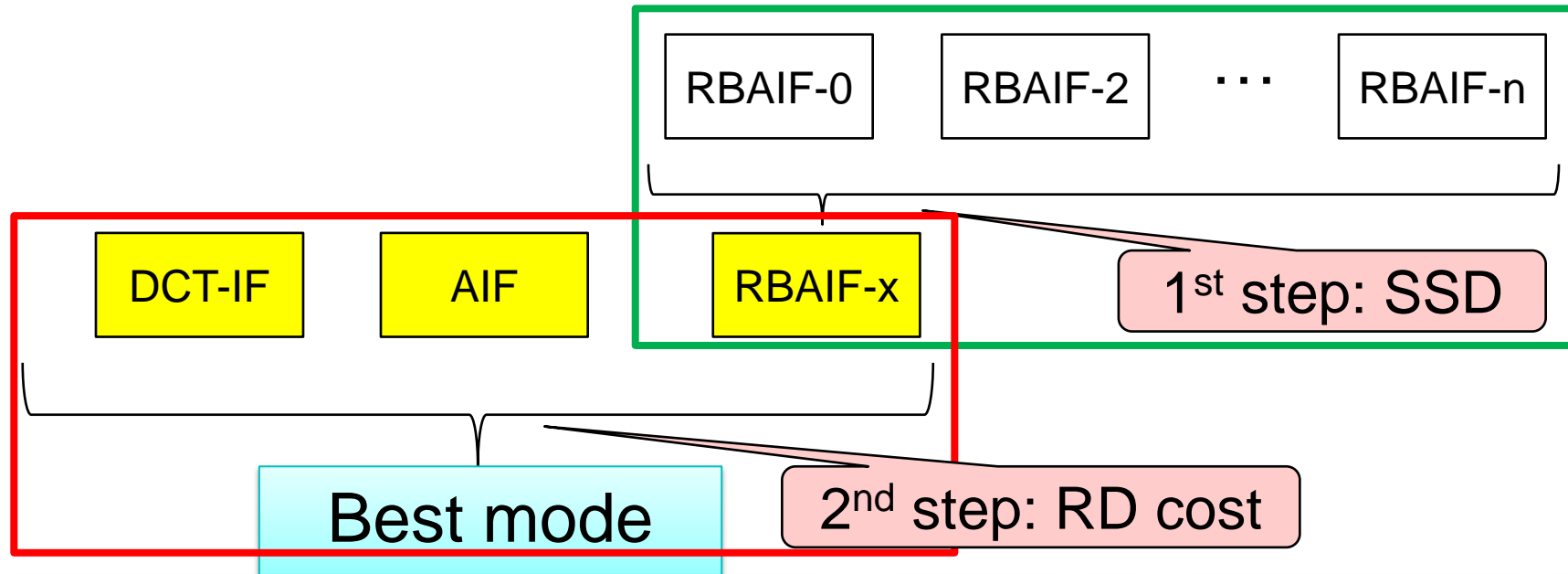- ❑ Demerit: increase of overhead information
  - – Bits of additional filter coefficients (each region has)
  - – Flag of segmentation mode (each frame has)
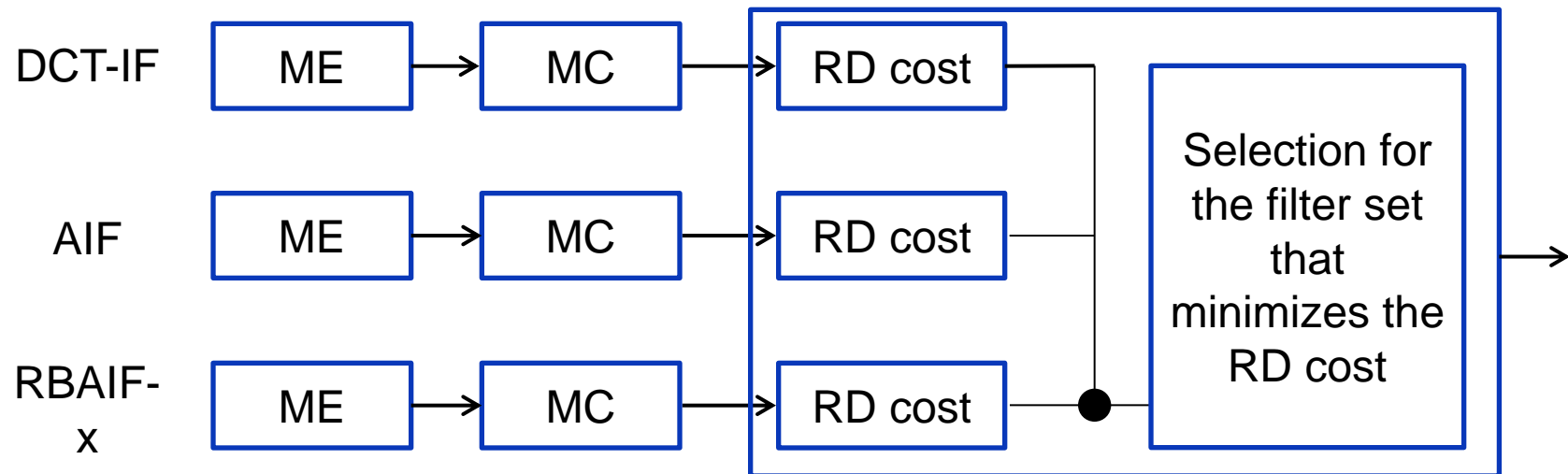
- ❑ RBAIF would be effective:
  - – for high-resolution images
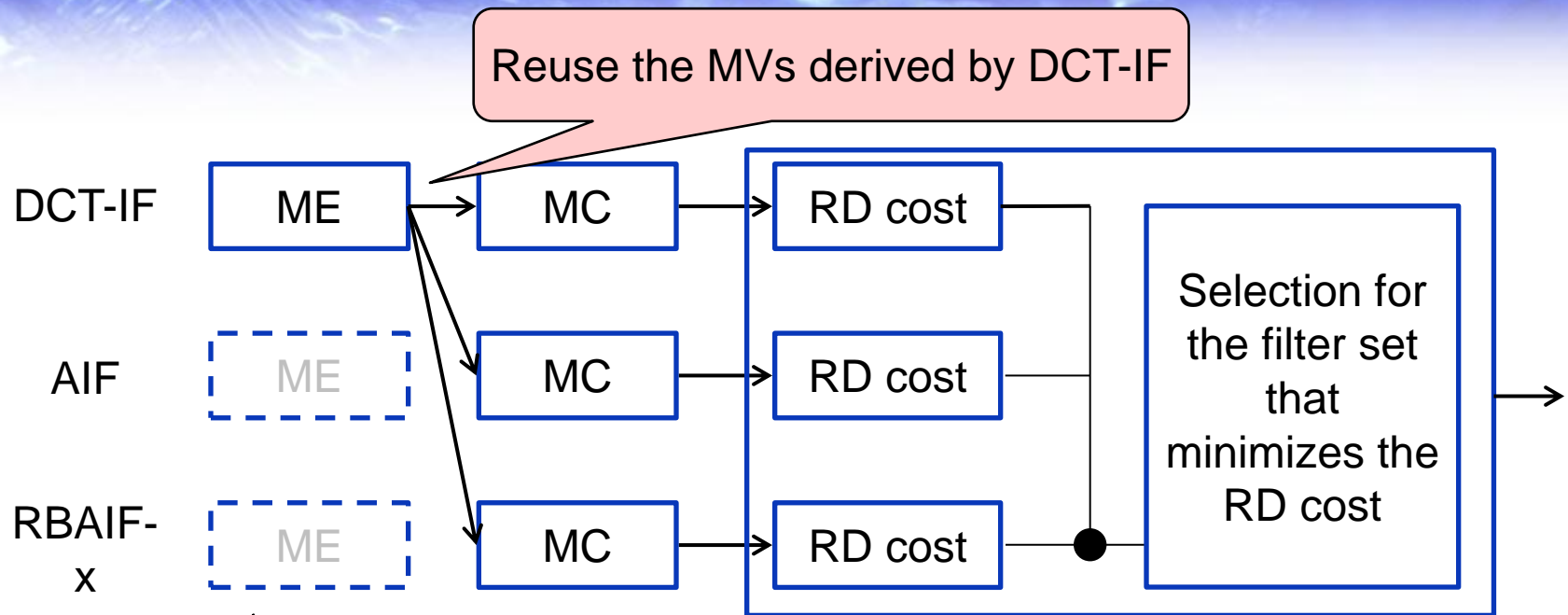 - – at high bit-rates

Algorithm for mode decision

❑ Proposed filter has two mode decision steps

- 1st step: Select the best segmentation mode (RBAIF-x) from the predefined set. In this step, SSD is used for the selection.

- 2nd step: Select the best mode from three modes (DCT-IF, AIF and RBAIF-x which is selected in 1st step). In this step, RD cost is used for the selection.

| RBAIF-0 | RBAIF-2 | ... | RBAIF-n |

| DCT-IF | AIF | RBAIF-x |

1st step: SSD

Best mode

2nd step: RD cost

Block diagram (Previous meeting, JCTVC-D150)

Block diagram (This meeting, JCTVC-E078)

Reuse the MVs derived by DCT-IF

DCT-IF → ME → MC → RD cost

AIF → ME → MC → RD cost

RBAIF-x → ME → MC → RD cost

Selection for the filter set that minimizes the RD cost

Skip two MEs that include
- intra/inter decision
- CU/PU/TU decision

Simulation

❑ Conditions

- Base software: HM2.0
- GOP: 4 cases (HE-RA, HE-LD, LC-RA, LC-LD)
- Test sequences: all HEVC sequences
- All frames
- QP: 4 points (22, 27, 32, 37)
- Other parameters were same as the default of encoder.cfg
- Segmentation mode: 7 (DCT-IF, SAIF, five modes of RBAIF)
- Filter: separable 8-tap filter (each coefficient is 6 bits)

❑ Results

- RD performance (BD-rate)
- Computational complexity

RD performance and complexity

	Random access			Random access LoCo		
	Y BD-rate	U BD-rate	V BD-rate	Y BD-rate	U BD-rate	V BD-rate
Class A	-0.2	-0.4	-0.5	-1.5	-0.7	-0.6
Class B	0.0	0.0	0.0	-0.1	-0.3	-0.4
Class C	0.0	0.0	0.0	-0.1	0.0	-0.1
Class D	0.0	0.2	0.1	0.0	0.1	0.0
Class E						
All	0.0	-0.1	-0.1	-0.4	-0.2	-0.3
Enc Time[%]	152%			146%		
Dec Time[%]	97%			99%		

	Low delay			Low delay LoCo		
	Y BD-rate	U BD-rate	V BD-rate	Y BD-rate	U BD-rate	V BD-rate
Class A						
Class B	-0.1	0.1	0.0	-1.3	0.2	0.6
Class C	0.0	0.1	0.1	-0.5	-0.1	-0.2
Class D	-0.1	0.1	0.0	-0.1	0.4	0.2
Class E	-0.2	-0.5	0.5	-3.0	0.1	-0.1
All	-0.1	0.0	0.1	-1.1	0.2	0.1
Enc Time[%]	136%			125%		
Dec Time[%]	98%			100%		

* These results were cross-verified by KDDI (JCTVC-E195)

Conclusion

❑ RBAIF was implemented in HM2.0 and evaluated

❑ Simulation results showed that
  – RBAIF provided coding gains:
    – HE-RA: 0.03%, HE-LD: 0.10%, LC-RA: 0.42%, LC-LD: 1.13%
    – Effective for high resolution images such as Class A, B, E
  – Encoding complexity: 125-150% of the HM2.0 anchor

❑ Future work includes
  – Reducing the encoding complexity
  – Investigating more effective segmentation methods

❑ Suggestion
  RBAIF is suggested to be incorporated into HEVC

Thank you, questions?

NTT

Previous Performance (JCTVC-D150)

	Random access		
	Y BD-rate	U BD-rate	V BD-rate
Class A	0.1	-0.1	0.0
Class B	-0.7	-0.6	-0.7
Class C	-0.3	-0.4	-0.4
Class D	0.0	0.2	0.4
Class E			
All	-0.3	-0.2	-0.2
Enc Time[%]	332%		
Dec Time[%]	99%		

	Low delay		
	Y BD-rate	U BD-rate	V BD-rate
Class A			
Class B	-0.9	-0.5	-0.7
Class C	-1.4	-0.5	-0.6
Class D	-2.2	-0.9	-0.1
Class E	-0.8	2.1	3.1
All	-1.3	-0.1	0.2
Enc Time[%]	332%		
Dec Time[%]	106%		