

JCTVC-H0136

**Non-CE8: Report on visual artifacts by ALF
virtual boundary processing and proposal on
the filtering process modification**

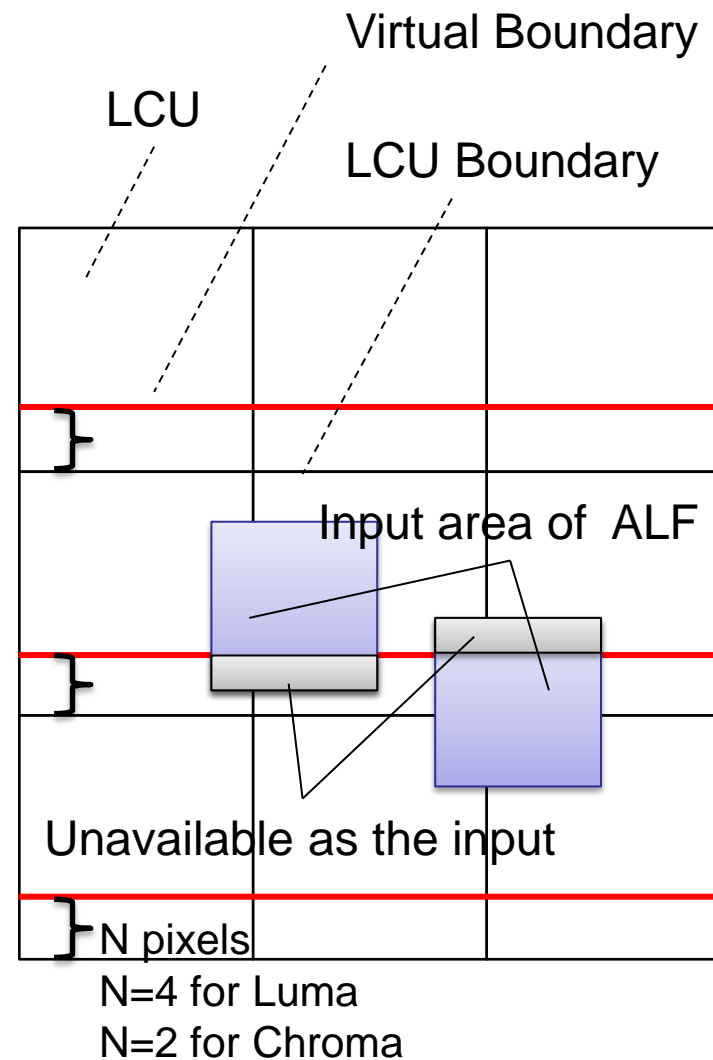
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Summary

- Visual artifacts caused by ALF Virtual Boundary(VB) processing are reported.
- Modification of Star5x5 filtering process around VB is proposed to minimize the artifacts in two methods.
- This contribution is cross-checked by NHK (JCTVC-H0163).

Introduction

- In HM5.0, ALF virtual boundary (VB) processing is introduced(*).
- VB is a line between 4 and 5 pixels (2 and 3 for Chroma) above each horizontal LCU boundary. ALF filtering process uses only pixels inside VB as input to reduce the line buffer for ALF.
- The VB processing contributes to reduce the line buffer for ALF. However, it might cause visual artifacts in the decode pictures in principle.



Study on visual artifacts by VB processing

- In addition to the common test, various kind of sequences are evaluated after HM5.0 release.
- “Fountain_chromakey” is one of the Japanese standard test sequences. The sequence is distributed by ITE(*) and ARIB(**) with fee. This contribution reports visual artifacts of the decode pictures found by the sequence.
- With and Without defined macro G212_CROSS9x9_VB condition are shown. Other encode conditions are LowDelayP_HE, QP=37.



”Fountain_chromakey”

A link for sample

<http://www.ite.or.jp/shuppan/sample/264-60p.mov>

(*) *The Institute of Image Information and Television Engineers* <http://www.ite.or.jp/en/>

(**) *The Association of Radio Industries and Businesses* <http://www.arib.or.jp/english/index.html>

With $VB_{(G212_CROSS9x9_VB \text{ is defined})}$, SAO OFF
QP=37, LowDelayP_HE, frame#75



Without $VB_{(G212_CROSS9x9_VB \text{ is not defined})}$, SAO OFF
QP=37, LowDelayP_HE, frame#75



X2 emphasize for projector

With VB processing

Without VB processing

Subjective evaluation result

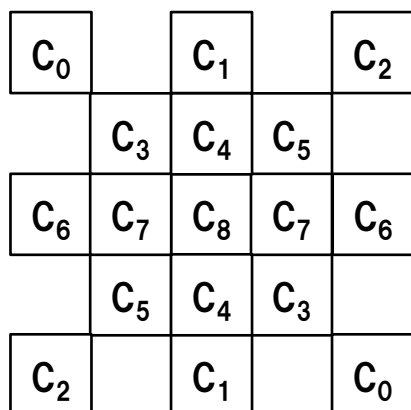
- It is reported that the artifacts are observed...
 - as a horizontal line in the sequence, which doesn't exist in the original.
 - clearly in moving picture due to the fix pattern.
 - more clearly when SAO is off.
 - even in QP=22.
- It is also reported that the artifacts are not observed...
 - in Cross9x9 filter only condition. But much more block noise is observed because the direction of water shower is diagonal.
 - when ALF is off. But much more block noise.

Analysis

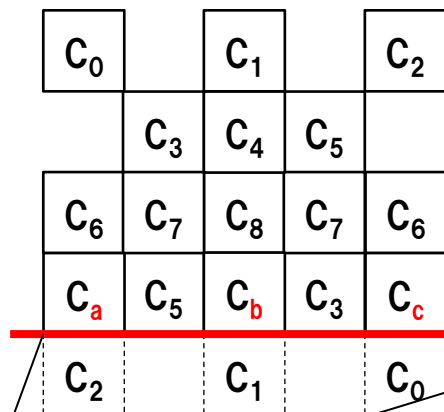
- The bitstream generated by HM5.0 encoder is analyzed to study which filter shape is selected. Star5x5 filter is mostly selected.
- Combining with the subjective results, it is presumed that the VB processing of Star5x5 shape filter causes the artifacts.
- In HM5.0, two special treatments are defined in Star5x5 VB processing. One is averaging process after the filtering, and the other is filter skip process.

Star 5x5 filtering process above VB

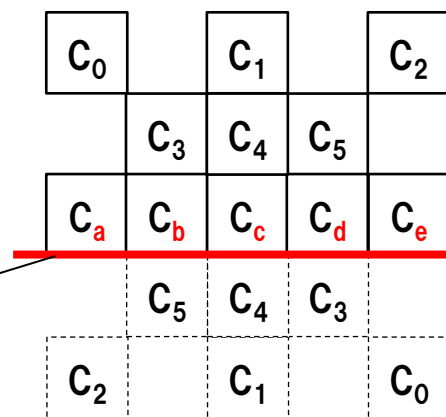
a) Normal case



b) 1 filter line is over VB



c) 2 filter lines are over VB



Virtual boundary

$$\begin{aligned} C_a &= C_2 \\ C_b &= C_1 + C_4 \\ C_c &= C_0 \end{aligned}$$

$$C_0 \sim C_8 = 0$$

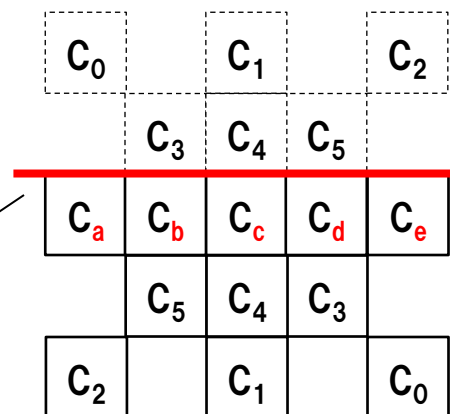
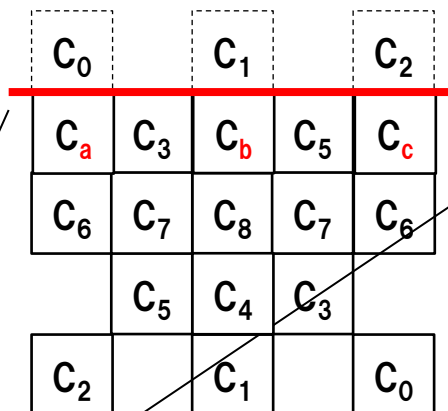
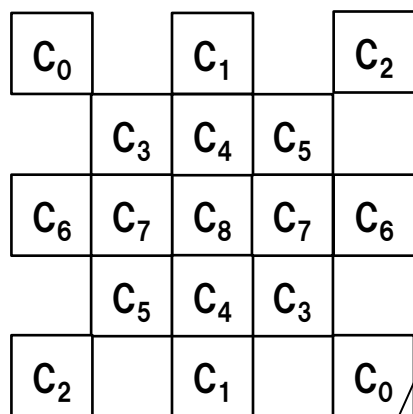
After the filtering, the result is averaged with the input pixel of the center.

Star 5x5 filtering process below VB

a) Normal case

b) 1 filter line is over VB

c) 2 filter lines are over VB



$$\begin{aligned}
 C_a &= C_0 \\
 C_b &= C_1 + C_4 \\
 C_c &= C_2
 \end{aligned}$$

$$C_0 \sim C_8 = 0$$

Virtual boundary

After the filtering, the result is averaged with the input pixel of the center.

Proposed modification

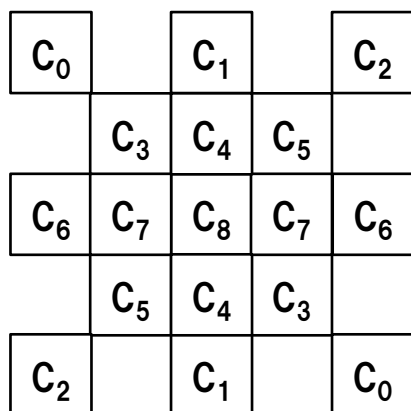
- Two methods are proposed.
- Method1 just removes the special treatments.
- Method2 is similar to Cross9x9 processing.

| | 1 filter line is over VB | 2 filter lines are over VB |
|---------|---|---|
| HM5.0 | Filtering with padding then averaging | Skip (No filtering) |
| Method1 | Filtering with padding No averaging | Filtering with padding No averaging |
| Method2 | Filtering with padding Coefficients change like Cross9x9 | Filtering with padding Coefficients change like Cross9x9 |

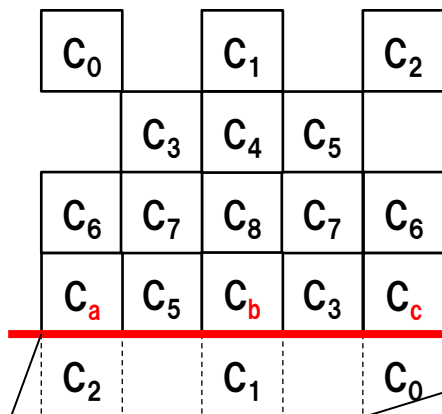
Proposed Method 1

Star 5x5 filtering process above VB

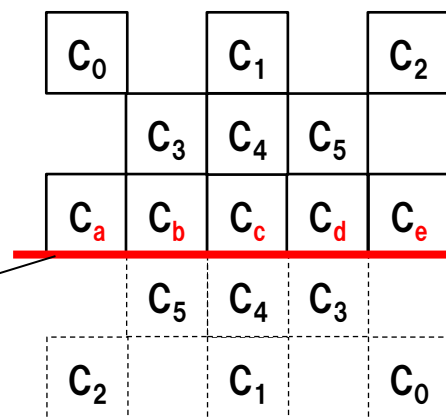
a) Normal case



b) 1 filter line is over VB



c) 2 filter lines are over VB



Virtual boundary

$$\begin{aligned} C_a &= C_2 \\ C_b &= C_1 + C_4 \\ C_c &= C_0 \end{aligned}$$

$$\begin{aligned} C_a &= C_2 + C_6 \\ C_b &= C_5 + C_7 \\ C_c &= C_1 + C_4 + C_8 \\ C_d &= C_3 + C_7 \\ C_e &= C_0 + C_6 \end{aligned}$$

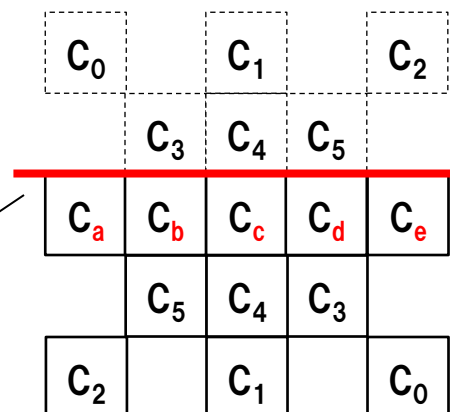
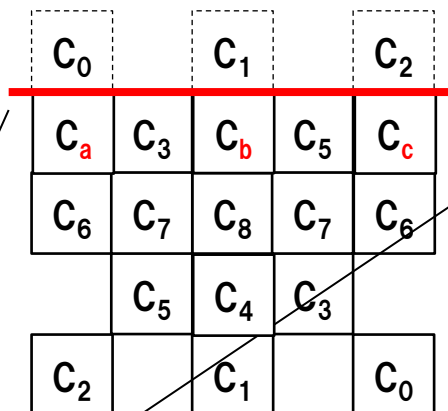
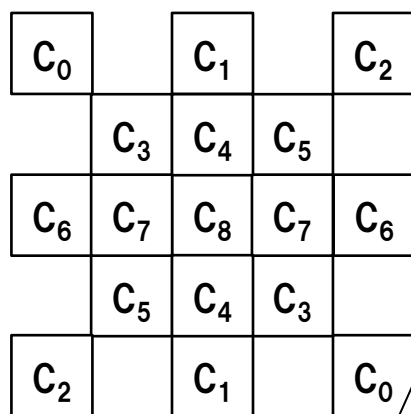
Proposed Method 1

Star 5x5 filtering process below VB

a) Normal case

b) 1 filter line is over VB

c) 2 filter lines are over VB



Virtual boundary

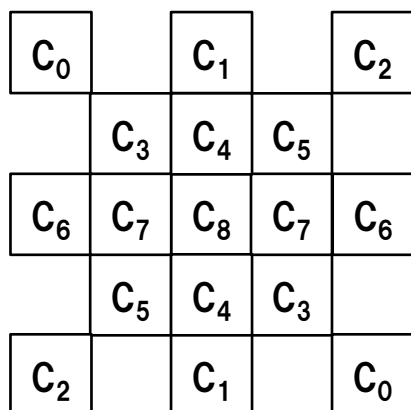
$$\begin{aligned} C_a &= C_0 \\ C_b &= C_1 + C_4 \\ C_c &= C_2 \end{aligned}$$

$$\begin{aligned} C_a &= C_0 + C_6 \\ C_b &= C_3 + C_7 \\ C_c &= C_1 + C_4 + C_8 \\ C_d &= C_5 + C_7 \\ C_e &= C_2 + C_6 \end{aligned}$$

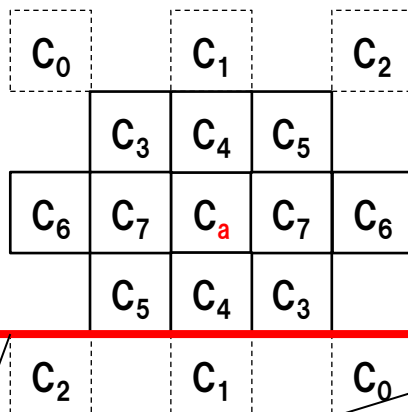
Proposed Method 2

Star 5x5 filtering process above VB

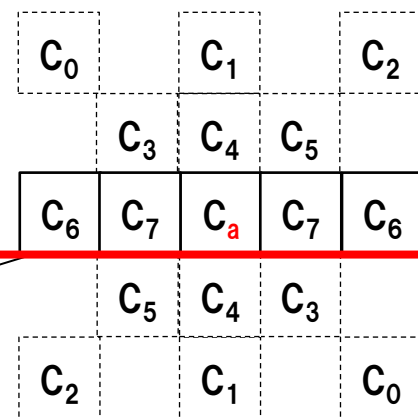
a) Normal case



b) 1 filter line is over VB



c) 2 filter lines are over VB



Virtual boundary

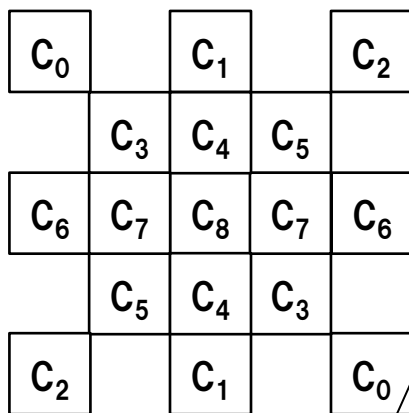
$$C_a = C_8 + 2 * (C_0 + C_1 + C_2)$$

$$C_a = C_8 + 2 * (C_0 + C_1 + C_2 + C_3 + C_4 + C_5)$$

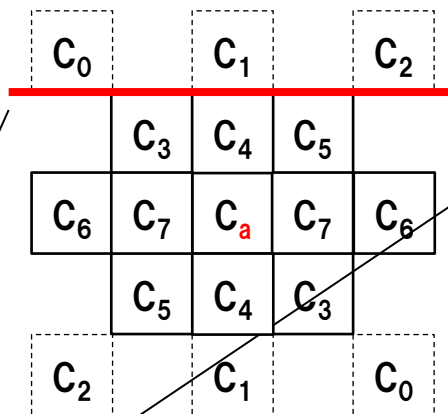
Proposed Method 2

Star 5x5 filtering process below VB

a) Normal case

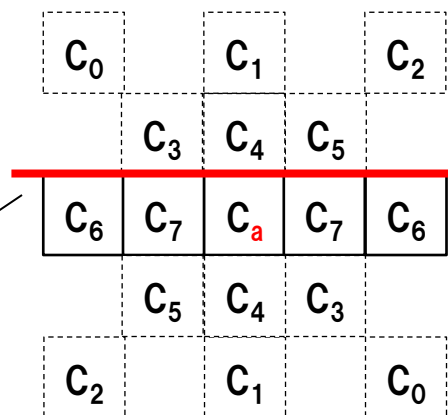


b) 1 filter line is over VB



$$C_a = C_8 + 2 * (C_0 + C_1 + C_2)$$

c) 2 filter lines are over VB



$$C_a = C_8 + 2 * (C_0 + C_1 + C_2 + C_3 + C_4 + C_5)$$

Virtual boundary

Method1 SAO OFF

QP=37, LowDelayP_HE, frame#75



Method2 SAO OFF

QP=37, LowDelayP_HE, frame#75



Objective result

Method1

| | All Intra HE | | | Random Access HE | | | Low delay B HE | | | Low delay P HE | | |
|----------------|--------------|------|------|------------------|------|-------|----------------|-------|-------|----------------|-------|-------|
| | Y | U | V | Y | U | V | Y | U | V | Y | U | V |
| Class A | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | -0.1% | | | | | | |
| Class B | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.1% | 0.1% | -0.1% | 0.1% | 0.1% |
| Class C | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | -0.2% | 0.0% | 0.1% | 0.1% | 0.0% |
| Class D | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | -0.2% | 0.0% | -0.4% | 0.3% | 0.0% | 0.0% | -0.4% |
| Class E | 0.0% | 0.0% | 0.0% | | | | -0.1% | 0.2% | -0.2% | -0.2% | -0.5% | -0.1% |
| Class F | 0.0% | 0.0% | 0.0% | -0.1% | 0.0% | 0.0% | -0.3% | -0.2% | -0.4% | 0.0% | 0.4% | 0.4% |
| Overall | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | -0.1% | -0.1% | 0.0% | 0.0% | 0.0% | 0.0% |
| | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | -0.1% | -0.1% | 0.0% | 0.0% | 0.0% | 0.0% |
| Enc Time[%] | 101% | | | 100% | | | 100% | | | 100% | | |
| Dec Time[%] | 99% | | | 100% | | | 99% | | | 100% | | |

Method2

| | All Intra HE | | | Random Access HE | | | Low delay B HE | | | Low delay P HE | | |
|----------------|--------------|------|------|------------------|-------|-------|----------------|-------|-------|----------------|-------|-------|
| | Y | U | V | Y | U | V | Y | U | V | Y | U | V |
| Class A | 0.1% | 0.0% | 0.0% | 0.3% | 0.0% | 0.0% | | | | | | |
| Class B | 0.0% | 0.0% | 0.0% | 0.1% | 0.0% | 0.1% | 0.1% | 0.1% | 0.2% | 0.1% | 0.1% | 0.0% |
| Class C | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.1% | 0.1% | 0.0% | -0.2% |
| Class D | 0.0% | 0.0% | 0.0% | 0.0% | -0.2% | -0.1% | 0.1% | -0.4% | 0.3% | 0.0% | 0.5% | 0.0% |
| Class E | 0.0% | 0.1% | 0.1% | | | | 0.6% | -0.1% | -0.1% | 0.8% | -0.1% | 0.1% |
| Class F | 0.0% | 0.0% | 0.0% | -0.1% | -0.1% | -0.1% | -0.2% | 0.0% | -0.5% | 0.1% | 0.3% | 0.3% |
| Overall | 0.0% | 0.0% | 0.0% | 0.1% | 0.0% | 0.0% | 0.1% | -0.1% | 0.0% | 0.2% | 0.2% | 0.0% |
| | 0.0% | 0.0% | 0.0% | 0.1% | -0.1% | 0.0% | 0.1% | -0.1% | 0.0% | 0.2% | 0.2% | 0.0% |
| Enc Time[%] | 100% | | | 100% | | | 100% | | | 100% | | |
| Dec Time[%] | 100% | | | 99% | | | 99% | | | 99% | | |

Conclusion

- The artifacts caused by VB processing should be minimized as possible.
- The proposed two methods reduces the artifacts in the exemplified sequence compared to HM5.0 while the bitrate increase is -0.1~0.0% for Method1 and 0.0~0.2% for Method2 in common test condition.
- It is recommended to adopt Method1 in both subjective and objective point of view.

Appendix

With VB (G212_CROSS9x9_VB is defined), SAO ON
QP=37, LowDelayP_HE, frame#75,



Without VB (G212_CROSS9x9_VB is not defined), SAO ON
QP=37, LowDelayP_HE, frame#75





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