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| *Title:* | On resampling process for outside-bounds samples | | |
| *Status:* | Input Document to JCT-VC | | |
| *Purpose:* | Proposal | | |
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# Abstract

This contribution proposes to modify the padding process in luma and chroma resampling to use the padding for reference-layer picture boundary instead of the padding for target-layer ROI boundary (scaled reference layer offset boundary). It is asserted that the modification unify padding process for the picture boundary and the ROI boundary. The method is implemented on SHM2.0. It is reported that no BD-rate changes are observed for all common test conditions (AI 2x, AI 1.5x, RA 2x, RA 1.5x RA SNR, LB 2x, LB 1.5x, LB SNR cases).

In addition, additional tests were done, in which scaled reference layer offsets were set to positive values (scaled\_ref\_layer\_left\_offset = 20, scaled\_ref\_layer\_right\_offset = 20, scaled\_ref\_layer\_top\_offset = 22, scaled\_ref\_layer\_bottom\_offset = 22). We also found a bug on SHM2.0 that the length of left-side padding area on a resampled reference layer was not correct and fixed the bug (SHM2.0+bugfix).

It is reported that BD-rate gains (EL only) of the proposal compared to SHM2.0+bugfix are 0.00%, -0.01% and -0.01% for AI 2x, RA 2x and LB 2x, respectively. Test packages for additional tests are also provided.

# Introduction

At the last meeting, resampling process of luma and chroma samples taking account of ROI (scaled reference layer offsets) was adopted [1].

Figure 1 shows the derivation process of the reference sample location (xRef, yRef) corresponding to the input sample location (xP, yP).

* Firstly, (xP, yP ) is converted into a boundary sample location (xP’, yP’) inside the bounds as specified follows.
  + Clip3( leftStartX, rightEndX –1, xP), Clip3(topStartX, bottomEndX-1, yP) (X=L, C) in subclause G.8.1.4.1.1 and G.8.1.4.1.2
* Secondly, (xRef, yRef) is derived with (xP’, yP’).

The first part is considered as a ROI paddding process (padding process for ROI bounds in the target layer). In terms of coding efficiency and complexity, we think it is better to use picture padding process in the reference layer instead of using the ROI padding process.



Figure 1: The derivation of a reference sample location (xRef, yRef) corresponding to an input sample location (xP,yP) outside bounds specified by scaled reference layer offsets.

# Proposed method

We propose to remove ROI padding process, which converts (xP, yP) to (xP', yP') as in Figure 1.

Figure 2 shows the proposed derivation process of a reference sample location (xRef, yRef) corresponding to an input sample location (xP,yP).

* Firstly, the reference sample location (xRef', yRef') is derived with (xP, yP ).
* Secondly, (xRef', yRef' ) is converted into the picture boundary location (xRef, yRef).
  + yPosRL = Clip3( 0, RefLayerPicHeightInSamplesX – 1, yRef + n – 1 ) (X=L, C) in (G-26) and (G-34)
  + Clip3( 0, RefLayerPicWidthInSamplesX– 1, xRef – fs/2 + 1 + i ) with i=0…fs-1, (X=L, C) in (G-27) and (G-36), where fs is filter size.

The second part corresponds to a padding process for picture bounds. Note that this padding process already exists. Therefore, with the proposed method, luma and chroma samples for ROI bounds can be re-sampled without using additional ROI padding process.

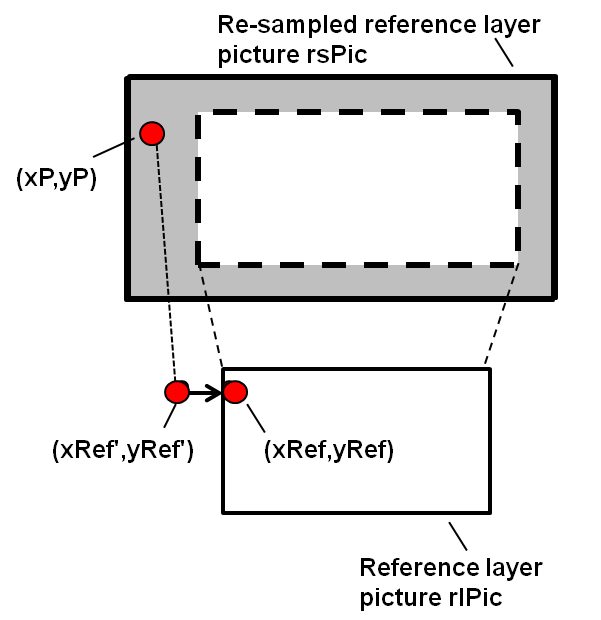


Figure 2: Proposed derivation of a reference sample location (xRef’, yRef’) corresponding to an input sample location (xP,yP) outside bounds specified by scaled reference layer offsets.

# Text changes

Changes are highlighted in yellow and cyan (removed part).

G.8.1.4.1.1 Resampling process of luma sample values

Input to this process is the reference luma sample array rlPicSampleL.

Output of this process is the resampled luma sample array rsPicSampleL.

~~The variables leftStart~~~~L~~~~, rightEnd~~~~L~~~~, topStart~~~~L~~~~, and bottomEnd~~~~L~~ ~~are derived as follows:~~

~~leftStart~~~~L~~ ~~= ScaledRefLayerLeftOffset  
rightEnd~~~~L~~ ~~= PicWidthInSamplesL – ScaledRefLayerRightOffset  
topStart~~~~L~~ ~~= ScaledRefLayerTopOffset  
bottomEnd~~~~L~~ ~~= PicHeightInSamplesL – ScaledRefLayerBottomOffset~~

The luma samples rsPicSampleL [ xP ][ yP ] with ( xP = 0 ... PicWidthInSamplesL – 1, yP = 0 ... PicHeightInSamplesL – 1) are derived by invoking the luma sample interpolation process specified in subclause G.8.1.4.1.3 with rlPicSampleL and luma sample location ~~( Clip3( leftStart~~~~L~~~~, rightEnd~~~~L~~~~– 1, xP ), Clip3( topStart~~~~L~~~~, bottomEnd~~~~L~~~~– 1, yP ) )~~ (xP, yP) given as inputs and rsPicSampleL[ xP ][ yP ] as output.

G.8.1.4.1.2 Resampling process of chroma sample values

Input to this process is the reference chroma sample array rlPicSampleC,

Output of this process is the resampled chroma sample array rsPicSampleC.

~~The variables leftStart~~~~C~~~~, rightEnd~~~~C~~~~, topStart~~~~C~~~~, and bottomEnd~~~~C~~ ~~are derived as follows:~~

~~leftStart~~~~C~~ ~~= ScaledRefLayerLeftOffset / SubWidthC  
rightEnd~~~~C~~ ~~= ( PicWidthInSamplesL– ScaledRefLayerRightOffset ) / SubWidthC  
topStart~~~~C~~ ~~= ScaledRefLayerTopOffset / SubHeightC  
bottomEnd~~~~C~~ ~~= ( PicHeightInSamplesL– ScaledRefLayerBottomOffset ) / SubHeightC~~

The chroma samples rsPicSampleC[ xPC ][ yPC ] with ( xPC = 0 ... PicWidthInSamplesC – 1, yPC = 0 ... PicHeightInSamplesC – 1) are derived by invoking the chroma sample interpolation process specified in subclause G.8.1.4.1.4 with rlPicSampleC and chroma sample location ~~( Clip3( leftStart~~~~C~~~~, rightEnd~~~~C~~~~‑ 1, xP~~~~C~~~~), Clip3( topStart~~~~C~~~~, bottomEnd~~~~C~~~~– 1, yP~~~~C~~~~) )~~ (xPC, yPC) given as inputs and rsPicSampleC[ xPC ][ yPC ] as output.

# Experimental results

## Common Test Condition

The proposed method is implemented on SHM2.0 and evaluation is done based on the test condition described in [2]. Table 1 shows the performance of the proposed method compared to SHM2.0. It was confirmed the proposed unification doesn’t change the coding efficiency.

Table 1: Performance of the proposal (ref. SHM2.0)



Table 2 shows the performance of the proposal compared to SHM2.0+bugfix. It was also confirmed that all results matched with the results compared to SHM2.0. The more detail results were provided in JCTVC-N0055\_vs\_SHM2.0.xlsm and JCTVC-N0055\_vs\_SHM2.0bugfix.xlsm, respectively.

Table 2: Performance of the proposal (ref. SHM2.0+bugfix)



## Additional Tests

In order to evaluate coding efficiency when scaled reference layer offsets having positive values, additional tests were done based on a following condition as described in Table 3. We generated sequences for base layer (BL) by cropping BL sequences of class B.

We also found a bug on SHM2.0 that the length of left-side padding area on a resampled reference layer was not correct as shown in Figure 3 and fixed the bug (SHM2.0+bugfix).

Table 4 shows the performance of the proposal compared to SHM2.0 + bugfix.

It is observed that BD-rate gains (EL only) of the proposal compared to SHM2.0+bugfix are 0.00%, -0.01% and -0.01% for AI 2x, RA 2x, LB 2x respectively. The more detail results were provided in JCTVC-N0055\_additional\_result1.xlsm.

Table 5 shows the performance of the proposal and SHM2.0 + bugfix compared to SHM2.0.

The more detail results of the proposal and SHM2.0 + bugfix compared to SHM2.0 were provided in JCTVC-N0055\_additional\_result2.xlsm and JCTVC-N0055\_additional\_result3.xlsm respectively.

Table 3: Test condition

|  |  |
| --- | --- |
| Sequences | Class B |
| The number of frames | Full frame |
| EL resolution | 1920x1080 (no change) |
| BL resolution | 920x496  (cropped from 960x540) |
| scaled\_ref\_layer\_left\_offset | 20 |
| scaled\_ref\_layer\_top\_offset | 22 |
| scaled\_ref\_layer\_right\_offset | 20 |
| scaled\_ref\_layer\_bottom\_offset | 22 |



Figure 3: resampled reference layer (BQTerrace, bl qp=26, el qp=26, frameNo=1) on SHM2.0. Red boxes indicate padding area.

Table 4: Performance of the proposal compared to SHM2.0 + bugfix



Table 5: Performance of the proposal and SHM2.0 + bugfix compared to SHM2.0

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | BD-Rate Y ( EL only ) | | | BD-Rate Y ( EL + BL) | | |
| AI 2x | RA 2x | LB 2x | AI 2x | RA 2x | LB 2x |
| SHM-2.0+bugfix | -27.59% | -20.05% | -13.72% | -18.47% | -13.13% | -8.95% |
| Proposal | -27.59% | -20.06% | -13.73% | -18.47% | -13.14% | -8.96% |

A patch file for the proposal and the bugfix is provided in JCTVC-N0055\_patch\_r1.

Macro settings related to the proposal and the bugfix are as follows:

//for proposal

#define BUGFIX\_RESAMPLE 0

#define JCTVC\_N0055 1 //0: ref, 1:proposal

//for bugfix ( SHM2.0 + bugfix )

#define BUGFIX\_RESAMPLE 1

#define JCTVC\_N0055 0 //0: ref, 1:proposal

Configure files (Class B) for the above additional tests are provided in cfg-shm20\_roi.

-BasketballDrive-2x.cfg

-BQTerrace-2x.cfg

-Cactus-2x.cfg

-Kimono-2x.cfg

-ParkScene-2x.cfg

A source code for cropping sequences is attached (framecrop.cpp). The usage is as follows:

$framecrop [input] [output] [width] [height] [offsetL] [offsetT] [offsetR] [offsetB]

e.x. $framecrop input output 960 540 20 22 20 22

The size of output is 920x496.

# Conclusion

This contribution proposes to modify the padding process in luma and chroma resampling to use the padding for reference-layer picture boundary instead of the padding for target-layer ROI boundary.

It is asserted that the modification is beneficial to remove the additional padding.

It is reported that no BD-rate changes are observed for all common test conditions (AI 2x, AI 1.5x, RA 2x, RA 1.5x RA SNR, LB 2x, LB 1.5x, LB SNR cases).

In addition, additional tests were done, in which scaled reference layer offsets were set to positive values (scaled\_ref\_layer\_left\_offset = 20, scaled\_ref\_layer\_right\_offset = 20, scaled\_ref\_layer\_top\_offset = 22, scaled\_ref\_layer\_bottom\_offset = 22). We also found a bug on SHM2.0 that the length of left-side padding area on a resampled reference layer was not correct and fixed the bug (SHM2.0+bugfix).

It is reported that BD-rate gains (EL only) of the proposal compared to SHM2.0+bugfix are 0.00%, -0.01% and -0.01% for AI 2x, RA 2x and LB 2x, respectively.

It is recommended to adopt this method into the next WD and SHM.

# Reference

1. J. Chen, et.al, “SHVC Working Draft 2”, JCTVC-M1008, Incheon, KR, 18–26 Apr. 2013.
2. X. Li, et.al, “ Common SHM test conditions and software reference configurations”, JCTVC-M1009, Incheon, KR, 18–26 Apr. 2013.

# Patent rights declaration(s)

**SHARP Corporation may have current or pending patent rights relating to the technology described in this contribution and, conditioned on reciprocity, is prepared to grant licenses under reasonable and non-discriminatory terms as necessary for implementation of the resulting ITU-T Recommendation | ISO/IEC International Standard (per box 2 of the ITU-T/ITU-R/ISO/IEC patent statement and licensing declaration form).**