



# SAO software cleanup and non-normative encoder-only bug-fixes

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# Overall Summary

- Three non-normative encoder-only bug-fixes
  - Pure encoder-only software bug-fixes
  - Negligible BD-rate change
- New SAO software implementation
  - Implemented on top of HM-11.0.
  - Remove legacies in HM (picture quadtree, fine granularity slices, adaptation parameter set)
  - Reduce the number of code lines by half (from 4000 to 2000)
  - Better code quality and readability
  - No run time increase
  - Also implemented on top of RExt, SHVC, and 3D-HEVC reference software packages

# Non-normative Encoder-only Bug-fixes

- Merge flag assignment fix
  - Problem: When `slice_sao_luma_flag` is equal to 0 and `slice_sao_chroma_flag` is equal to 1, merge flags are not assigned correctly during RDO.
  
- Rate calculation fix
  - Problem: Regardless of what `slice_sao_luma_flag` and `slice_sao_chroma_flag` are, SAO type index rate is always counted during RDO.
  
- Boundary condition fix for 0-degree EO
  - Problem: When the CTU is at the bottom boundary of a picture, the bottom sample lines of the CTU are unnecessarily skipped for 0-degree EO statistics collection.

# Non-normative Encoder-only Bug-fixes

- Anchor:
  - HM-11.0
- Test:
  - HM-11.0 with non-normative encoder-only bug-fixes
- Results:
  - Negligible BD-rate change
  - No run time increase

	All Intra Main			All Intra Main10		
	Y	U	V	Y	U	V
Class A	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Class B	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Class C	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Class D	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Class E	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
<b>Overall</b>	<b>0.0%</b>	<b>0.0%</b>	<b>0.0%</b>	<b>0.0%</b>	<b>0.0%</b>	<b>0.0%</b>
	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Class F	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Enc Time[%]	100%			100%		
Dec Time[%]	100%			100%		

	Random Access Main			Random Access Main10		
	Y	U	V	Y	U	V
Class A	0.1%	0.0%	0.1%	0.0%	0.0%	0.0%
Class B	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Class C	0.0%	0.0%	-0.1%	0.0%	0.0%	0.0%
Class D	0.0%	0.0%	0.0%	0.0%	-0.1%	0.0%
Class E						
<b>Overall</b>	<b>0.0%</b>	<b>0.0%</b>	<b>0.0%</b>	<b>0.0%</b>	<b>0.0%</b>	<b>0.0%</b>
	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Class F	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Enc Time[%]	100%			100%		
Dec Time[%]	101%			100%		

	Low delay B Main			Low delay B Main10		
	Y	U	V	Y	U	V
Class A						
Class B	0.0%	0.0%	-0.4%	0.0%	0.0%	-0.1%
Class C	0.0%	0.0%	-0.1%	0.0%	0.1%	0.1%
Class D	0.0%	0.2%	0.1%	0.0%	0.2%	0.1%
Class E	0.0%	-0.1%	0.0%	0.0%	0.1%	0.1%
<b>Overall</b>	<b>0.0%</b>	<b>0.0%</b>	<b>-0.1%</b>	<b>0.0%</b>	<b>0.1%</b>	<b>0.0%</b>
	0.0%	0.0%	-0.1%	0.0%	0.1%	0.0%
Class F	0.0%	0.4%	-0.3%	0.0%	0.3%	0.1%
Enc Time[%]	100%			100%		
Dec Time[%]	100%			100%		

	Low delay P Main			Low delay P Main10		
	Y	U	V	Y	U	V
Class A						
Class B	0.0%	-0.2%	-0.1%	0.0%	0.2%	-0.1%
Class C	0.0%	-0.4%	0.2%	0.0%	-0.1%	-0.2%
Class D	0.0%	-0.2%	0.0%	0.0%	0.4%	-0.2%
Class E	0.0%	0.2%	0.3%	0.0%	0.0%	0.0%
<b>Overall</b>	<b>0.0%</b>	<b>-0.2%</b>	<b>0.1%</b>	<b>0.0%</b>	<b>0.1%</b>	<b>-0.1%</b>
	0.0%	-0.2%	0.2%	0.0%	0.1%	-0.1%
Class F	0.1%	-0.2%	0.3%	0.0%	-0.1%	0.0%
Enc Time[%]	99%			100%		
Dec Time[%]	98%			100%		

# New SAO Software Implementation

- Implemented on top of HM-11.0.
- Include the three non-normative encoder-only bug-fixes
- Remove legacies related to SAO
  - SAO picture quadtree
  - APS
  - Fine granularity slice
- Reduce the number of code lines by half
  - From around 4000 lines to 2000 lines
- No run time increase

# New SAO software implementation

- Anchor:
  - HM-11.0 with non-normative encoder-only bug-fixes
- Test:
  - New SAO software implementation
- Results:
  - Bitstreams and decoded yuv results are fully matched between anchor and test.
  - No run time increase

	All Intra Main			All Intra Main10		
	Y	U	V	Y	U	V
Class A	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Class B	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Class C	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Class D	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Class E	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
<b>Overall</b>	<b>0.0%</b>	<b>0.0%</b>	<b>0.0%</b>	<b>0.0%</b>	<b>0.0%</b>	<b>0.0%</b>
	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Class F	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Enc Time[%]		99%			99%	
Dec Time[%]		101%			101%	

	Random Access Main			Random Access Main10		
	Y	U	V	Y	U	V
Class A	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Class B	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Class C	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Class D	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Class E						
<b>Overall</b>	<b>0.0%</b>	<b>0.0%</b>	<b>0.0%</b>	<b>0.0%</b>	<b>0.0%</b>	<b>0.0%</b>
	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Class F	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Enc Time[%]		100%			100%	
Dec Time[%]		99%			100%	

	Low delay B Main			Low delay B Main10		
	Y	U	V	Y	U	V
Class A						
Class B	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Class C	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Class D	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Class E	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
<b>Overall</b>	<b>0.0%</b>	<b>0.0%</b>	<b>0.0%</b>	<b>0.0%</b>	<b>0.0%</b>	<b>0.0%</b>
	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Class F	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Enc Time[%]		100%			100%	
Dec Time[%]		100%			99%	

	Low delay P Main			Low delay P Main10		
	Y	U	V	Y	U	V
Class A						
Class B	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Class C	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Class D	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Class E	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
<b>Overall</b>	<b>0.0%</b>	<b>0.0%</b>	<b>0.0%</b>	<b>0.0%</b>	<b>0.0%</b>	<b>0.0%</b>
	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Class F	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Enc Time[%]		100%			100%	
Dec Time[%]		101%			99%	

# New SAO software implementation

- The corresponding modifications for HEVC extensions are also provided for
  - RExt: HM-10.1+RExt-3.0
  - SHVC: SHM-2.0
  - 3D-HEVC: HTM-DEV-0.3-dev2 (Rev. 538)

# Conclusions

- Three non-normative encoder-only bug-fixes are proposed
  - Pure encoder-only software bug-fixes
  - Negligible BD-rate change
- New SAO implementation is proposed for HM software
  - No run time increase
  - Reduce the number of code lines by half (4000 => 2000)
  - Better code quality and readability
- Corresponding modifications for RExt, SHVC, and 3D-HEVC are also provided