

# Coding Efficiency Evaluation of AV1 Coding Tools

Ryan Lei  
Video Codec Architect,  
Intel Corp.  
[ryan.lei@intel.com](mailto:ryan.lei@intel.com)



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# Agenda

- Motivation of the Study
- Test Configurations
- Analysis of Selected Result
- Summary and Proposals

# Motivation

- During AV1 development, coding gain of individual tool was not evaluated using the same baseline.
- Coding tools consolidation at the end of development cycle was not ideal.
- For software or hardware encoder implementation, it is important to understand the gain of individual coding tools.
  - “Tool-on” vs “tool-off” tests

# Test Configuration

- AV1 Reference code was modified to support passing control flags through config file to turn on/off each coding tool.
  - Code base: [50b3c93](#)
  - 35 flags are added to control the encoder behavior.
    - Patch: <https://aomedia-review.google.com/c/aom/+96983>
- 3 Test Configurations:
  - All Intra:
    - `aomenc -c Test_0.cfg --codec=av1 -v --psnr --ivf --disable-warning-prompt --frame-parallel=0 --tile-columns=0 --cpu-used=0 --kf-min-dist=1 --kf-max-dist=1 --end-usage=q --cq-level=22 --min-q=22 --max-q=22 -o xxx.ivf xxx.y4m`
  - Low Delay:
    - `aomenc -c Test_0.cfg --codec=av1 -v --psnr --ivf --disable-warning-prompt --frame-parallel=0 --tile-columns=0 --cpu-used=0 --kf-min-dist=1000 --kf-max-dist=1000 --passes=1 --auto-alt-ref=0 --lag-in-frames=0 --end-usage=q --cq-level=22 --min-q=22 --max-q=22 -o xxx.ivf xxx.y4m`
  - High Delay:
    - `aomenc -c Test_0.cfg --codec=av1 -v --psnr --ivf --disable-warning-prompt --frame-parallel=0 --tile-columns=0 --cpu-used=0 --kf-min-dist=1000 --kf-max-dist=1000 --passes=2 --auto-alt-ref=2 --lag-in-frames=25 --end-usage=q --cq-level=22 --min-q=22 --max-q=22 -o xxx.ivf xxx.y4m`
- Test Sequences: objective-1-fast.
- Constant Quality Mode with QP= [22, 27, 32, 37]
  - QP modulation is turned off.

# Control Flags

Category	Flags
Partition and subblock size control	<b>SuperBlockSize, MaxPartitionSize, MinPartitionSize, DisableRectPartitionType, DisableABPartitionType, Disable1to4PartitionType</b>
Intra Coding Tools	<b>DisableIntraAngleDelta, DisablePaethIntra, DisableSmoothIntra, DisableIntraEdgeFilter, DisableFilterIntra, DisableIBC, DisableCFL, DisablePalette</b>
Transform Tools	<b>DisableFlipIdtx, DisableTx64x64, ReducedTxTypeSet, TxSizeSearchMethod</b>
Inter Coding Tools	<b>ReducedReferenceSet, DisableOBMC, DisableWarpMotion, DisableGlobalMotion, DisableRefFrameMV, DisableDualFilter, DisableOneSidedComp, DisableMaskedComp, DisableDiffWtdComp, DisableInterInterWedge, DisableDistWtdComp, DisableInterIntraComp, DisableInterIntraWedge, DisableSmoothInterIntra,</b>
In-Loop Filters	<b>DisableCDEF, DisableLR</b>
Trellis Quantization	<b>DisableTrellisQuant</b>

Sample.cfg

```

1  #sample config file
2  SuperBlockSize = 128           #super block size. 0, 64 or 128
3  MaxPartitionSize = 128       #max partition size(8, 16, 32, 64, 128)
4  MinPartitionSize = 4        #min partition size(4, 8, 16, 32, 64)
5  DisableRectPartitionType = 0 #disable rectangle partition type
6  DisableABPartitionType = 0  #disable AB partition type
7  Disable1to4PartitionType = 0 #disable 1to4 and 4to1 partition type
8  DisableIntraAngleDelta = 0  #disable intra angle delta
9  DisablePaethIntra = 0       #disable paeth intra
10 DisableSmoothIntra = 0      #disable intra smooth mode
11 DisableIntraEdgeFilter = 0  #disable intra edge filter
12 DisableFilterIntra = 0     #disable filter intra
13 DisableIBC = 0             #disable Intra Block Copy
14 DisableCFL = 0             #disable chroma from luma prediction
15 DisablePalette = 0         #disable Palette
16 DisableFlipIdtx = 0        #disable flip and identity transform
17 DisableTx64x64 = 0         #disable 64x64 transform
18 ReducedTxTypeSet = 0       #use reduced transform type set
19 TxSizeSearchMethod = 0     #0:FULL_RD, 1 : FAST_RD, 2 : USE_LARGEST
20 ReducedReferenceSet = 0    #use reduced reference frame set
21 DisableOBMC = 0           #disable OBMC
22 DisableWarpMotion = 0     #disable Warped Motion
23 DisableGlobalMotion = 0   #disable global motion
24 DisableRefFrameMV = 0     #disable ref mv
25 DisableDualFilter = 0     #disable dual interpolation filter
26 DisableOneSidedComp = 0   #disable one sided compound mode
27 DisableMaskedComp = 0     #disable masked compound prediction
28 DisableDiffWtdComp = 0    #disable difference weighted compound mode
29 DisableInterInterWedge = 0 #disable inter/inter wedge comp
30 DisableDistWtdComp = 0    #disable distant weighted compound mode
31 DisableInterIntraComp = 0 #disable inter/intra compound mode.
32 DisableInterIntraWedge = 0 #disable inter/intra wedge comp
33 DisableSmoothInterIntra = 0 #disable smooth inter/intra
34 DisableCDEF = 0           #disable CDEF filter
35 DisableLR = 0             #disable Loop Resotoration Filter
36 DisableTrellisQuant = 0   #disable trellis quantization
37

```

# Test Configuration

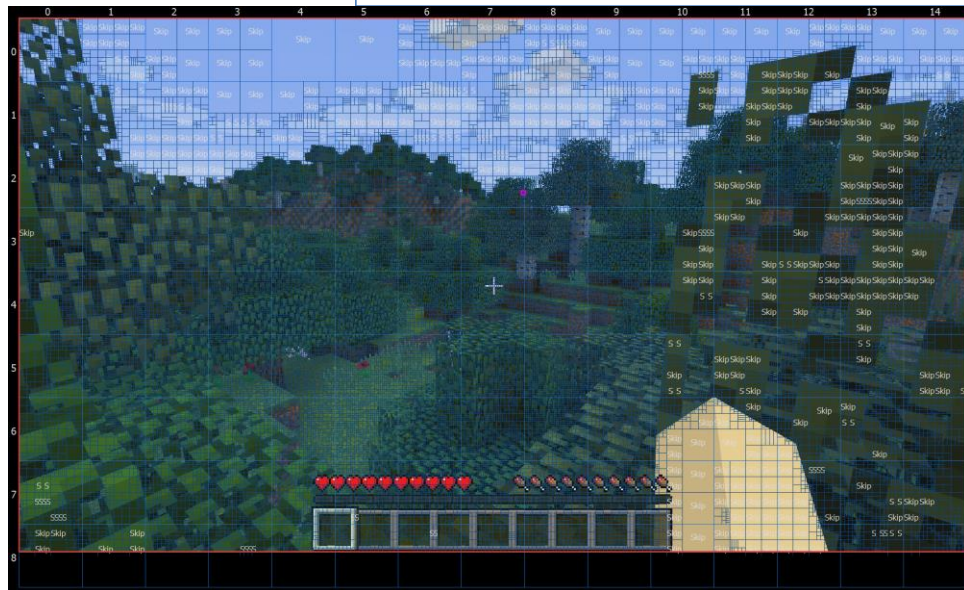
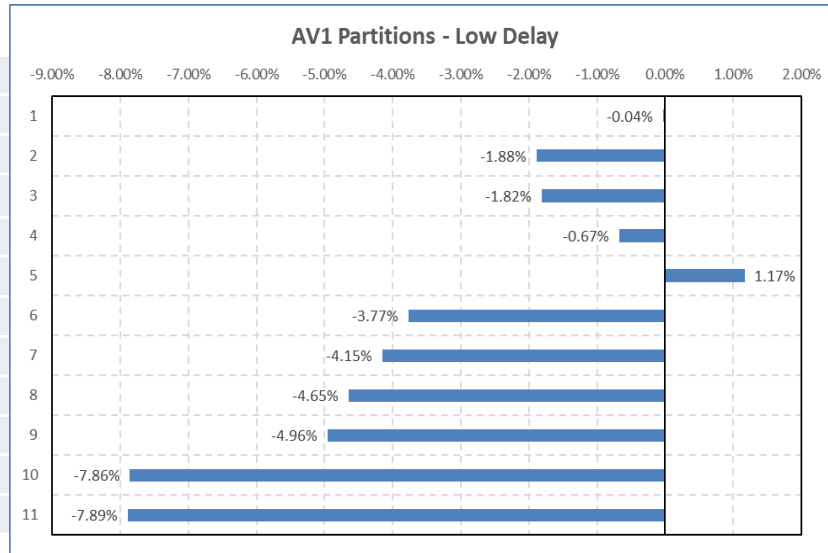
- Baseline is the configuration with majority of the new coding tools disabled, so encoder behavior and quality is close to VP9.
  - SuperBlockSize=64, MaxPartitionSize=64, MinPartitionSize=8, DisableRectPartitionType=1.
  - Some coding tools, such as new entropy coding engine and deblocking are always enabled.
- ~27 sub tests for All Intra, ~54 sub tests for Low Delay and High Delay configurations.
- BDRATE based on average Y/U/V PSNR are calculated as the quality metric.
  - Negative BDRATE indicates better coding efficiency than the baseline.



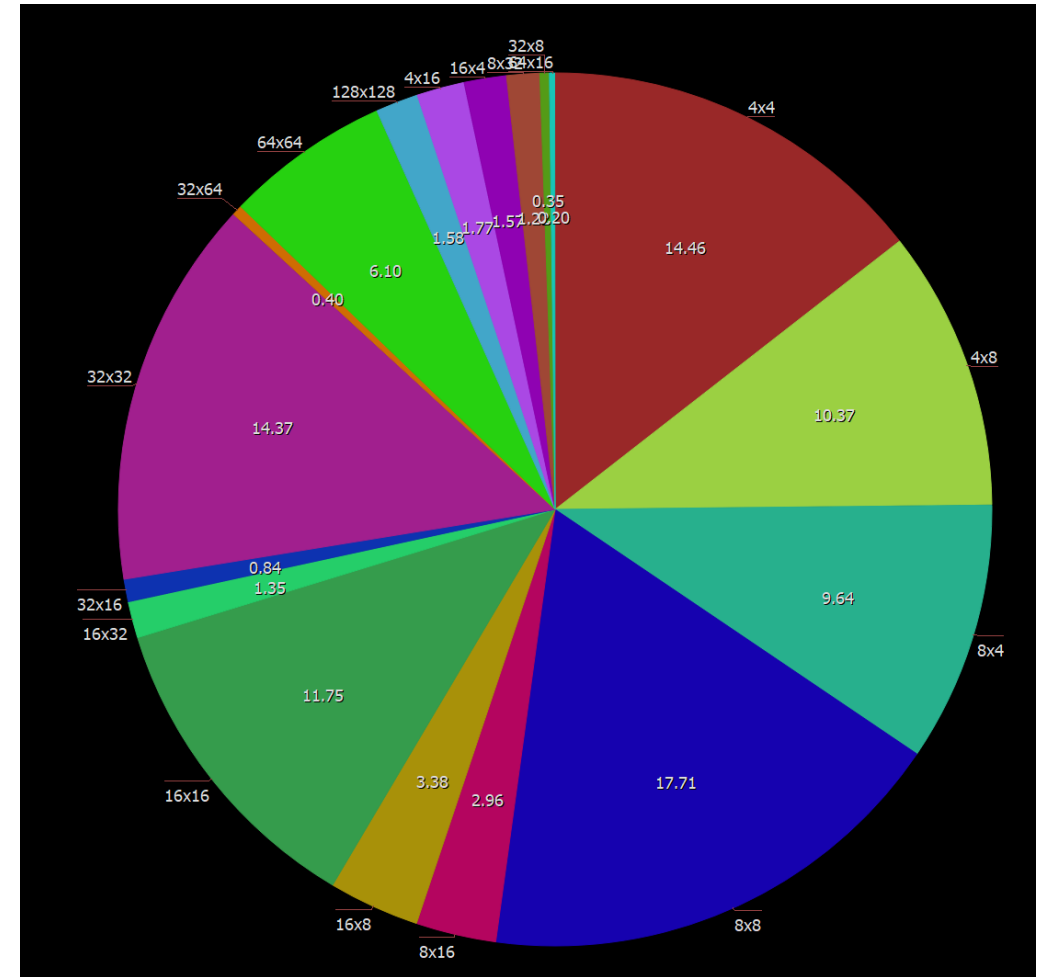


# Partitioning

- 0 64x64 super block, min partition = 8x8
- 1 128x128 super block
- 2 4x4 to 128x128 partitions
- 3 max partition 64x64, min partition 4x4
- 4 max partition 32x32, min partition 4x4
- 5 max partition 32x32, min partition 8x8
- 6 rect partition type
- 7 rect + AB partition
- 8 rect + 1:4 partition
- 9 all partition from 8x8 to 64x64
- 10 all partition from 4x4 to 64x64
- 11 all partition from 4x4 to 128x128



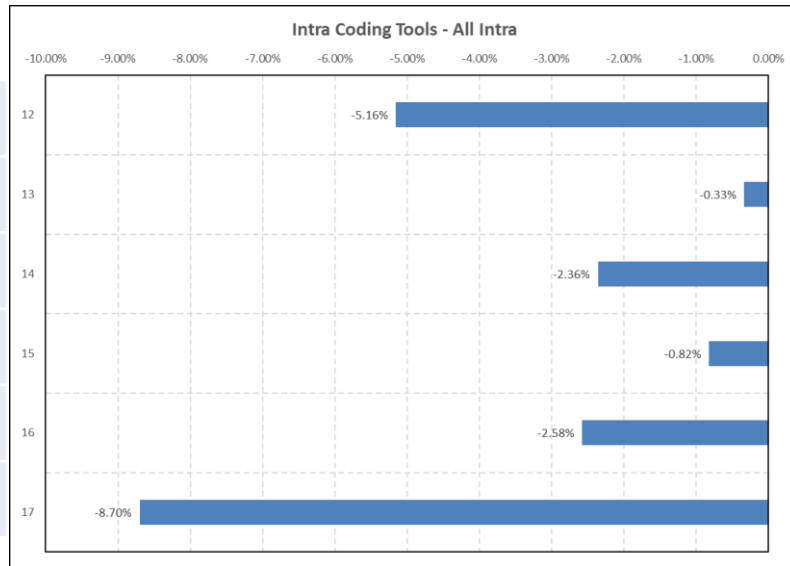
Minecraft



Area normalized block size distribution for Minecraft



# Intra Coding Tools



12 enable intra angle delta

13 enable paeth intra

14 enable smooth intra

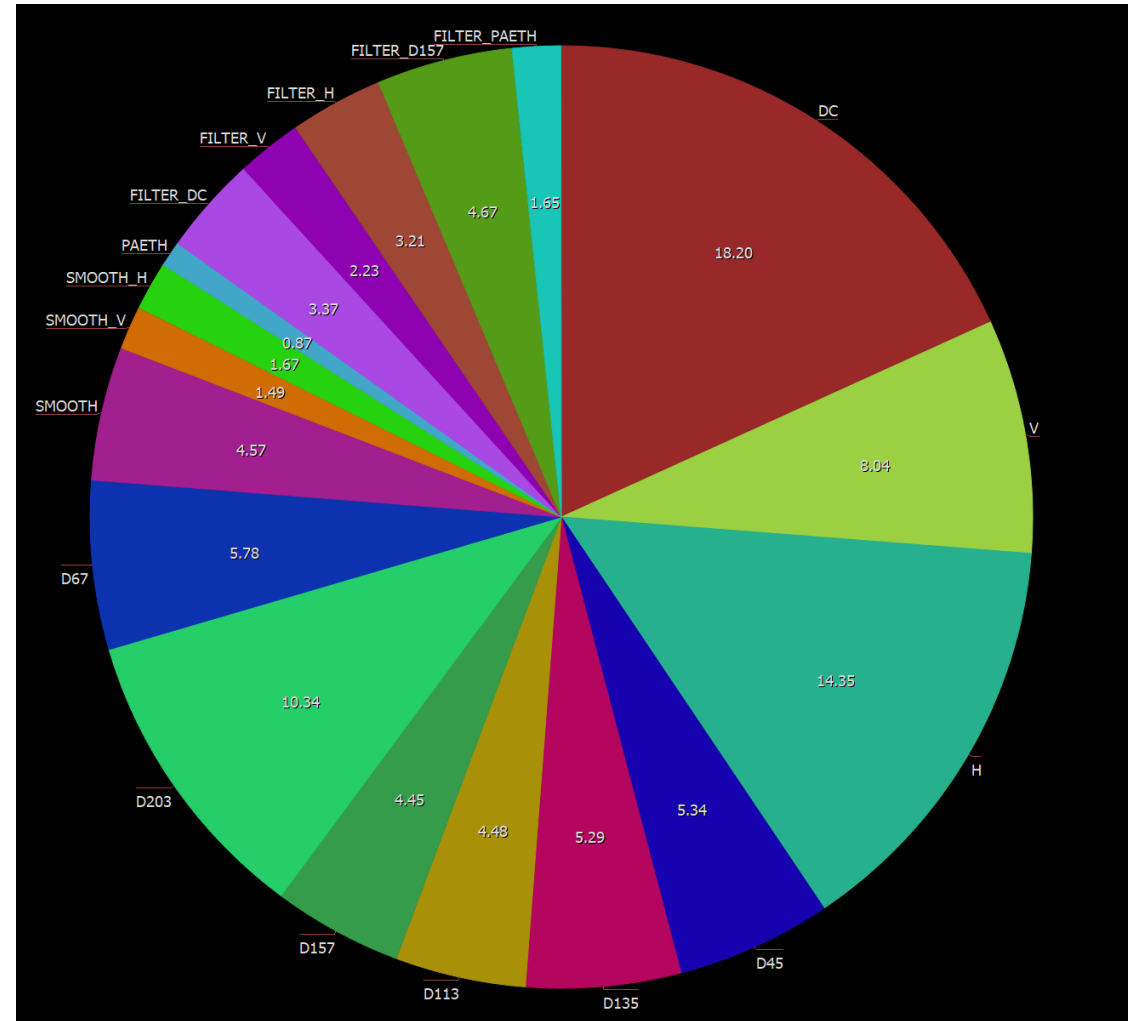
15 enable intra edge filter

16 enable filter intra

17 enable all intra tools



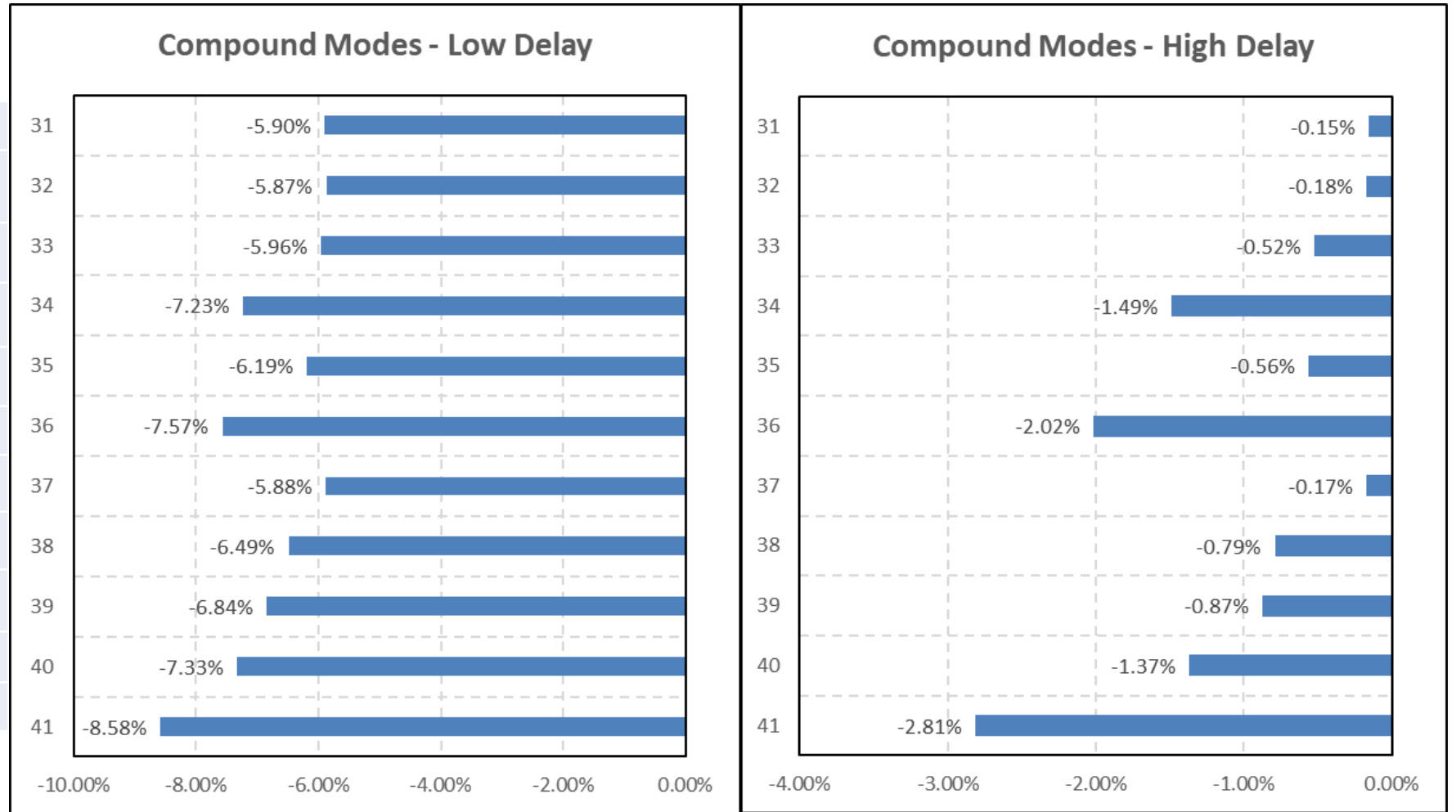
Netflix\_TunnelFlag



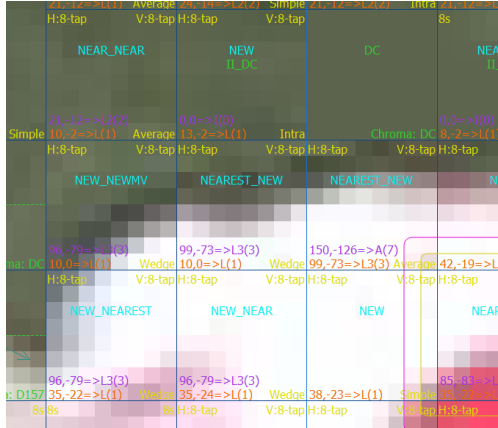
Area normalized intra mode distribution for Netflix\_TunnelFlag

# Compound Modes

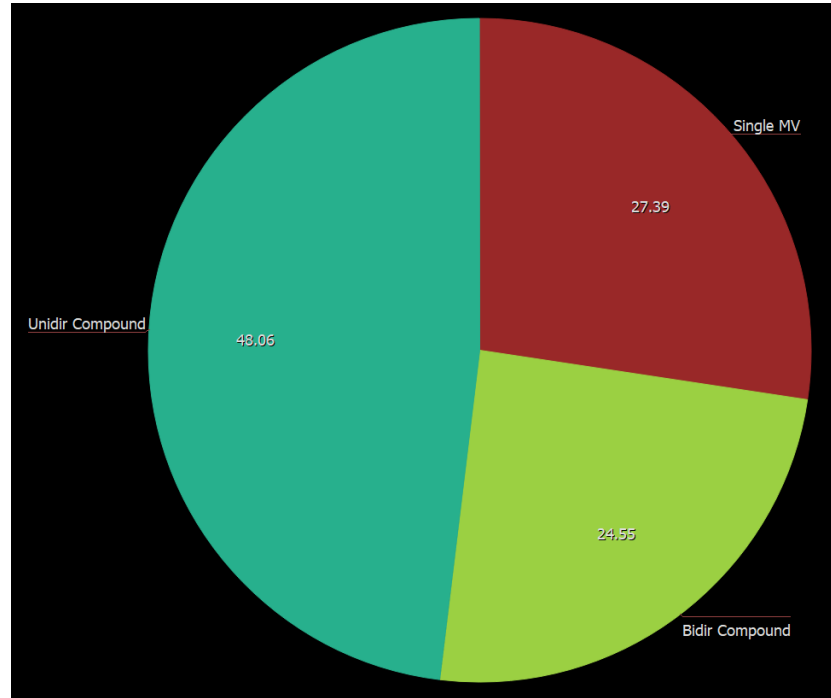
- 31 one sided compound
- 32 enable one sided comp + masked compound, use COMPOUND\_AVERAGE only
- 33 enable one sided comp + difference weighted compound
- 34 enable one sided comp + inter inter wedge compound
- 35 enable one sided comp + distance weighted compound
- 36 all inter compound mode
- 37 inter intra compound mode
- 38 inter intra wedge compound
- 39 inter intra smooth compound
- 40 all inter intra compound mode
- 41 all compound mode



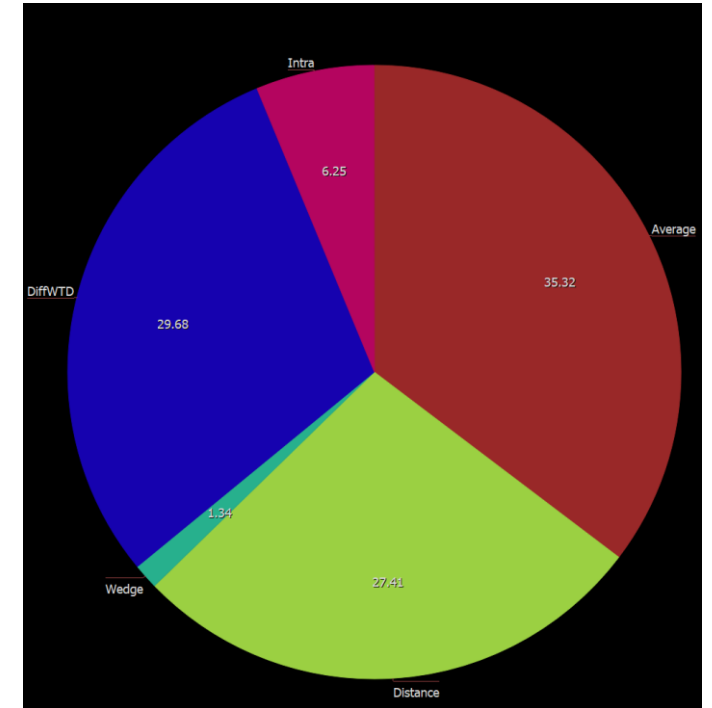
# Compound Modes



Touchdown\_pass



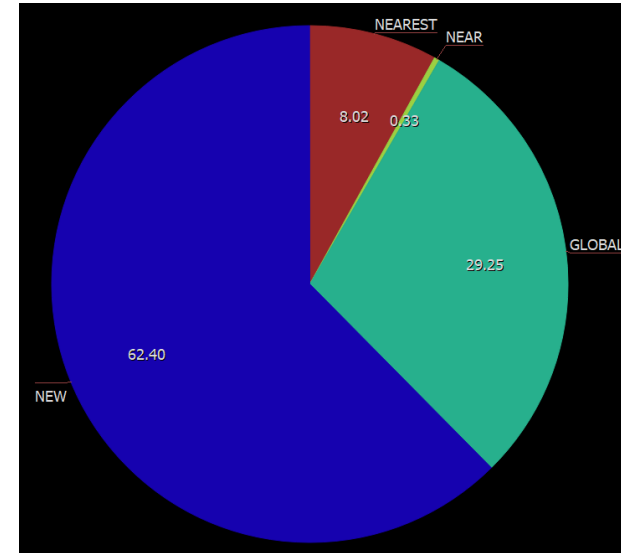
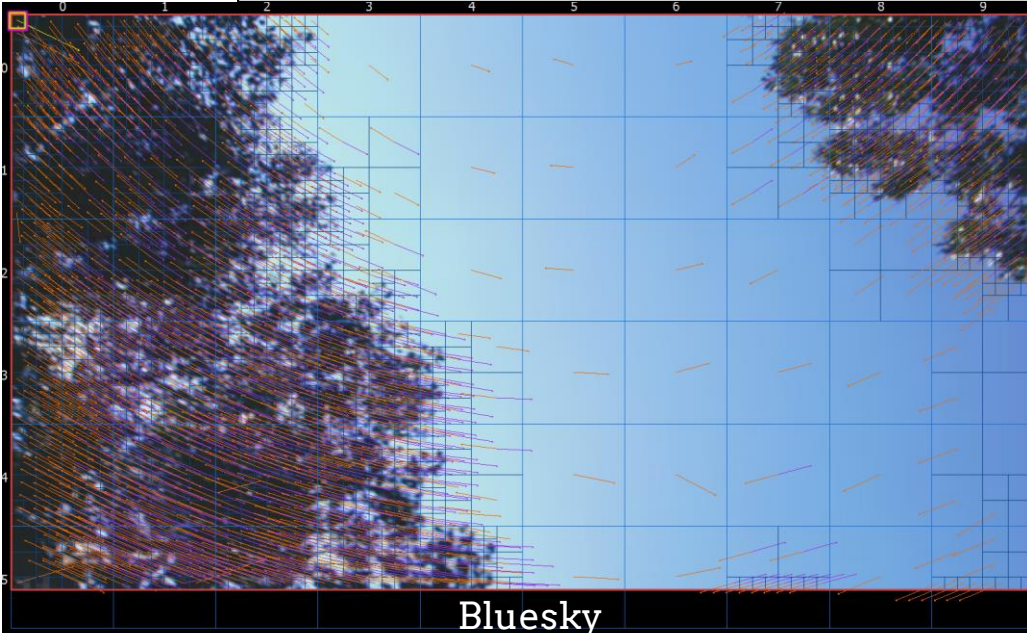
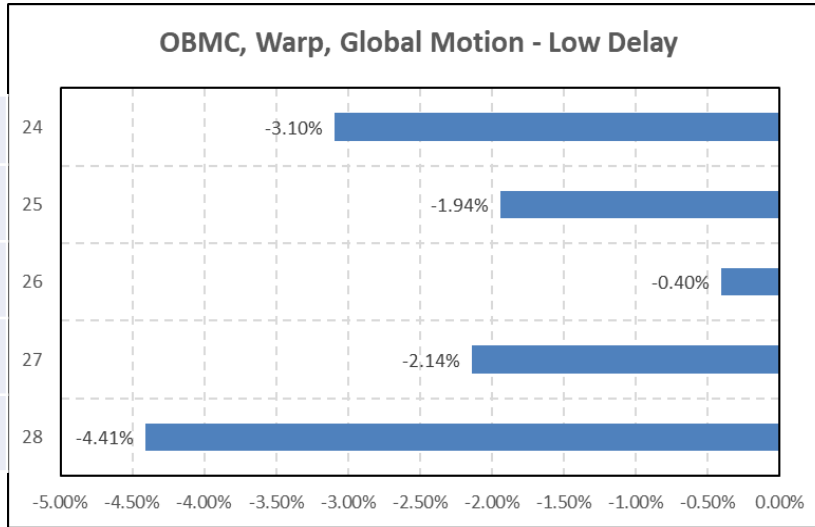
One-Sided Compound



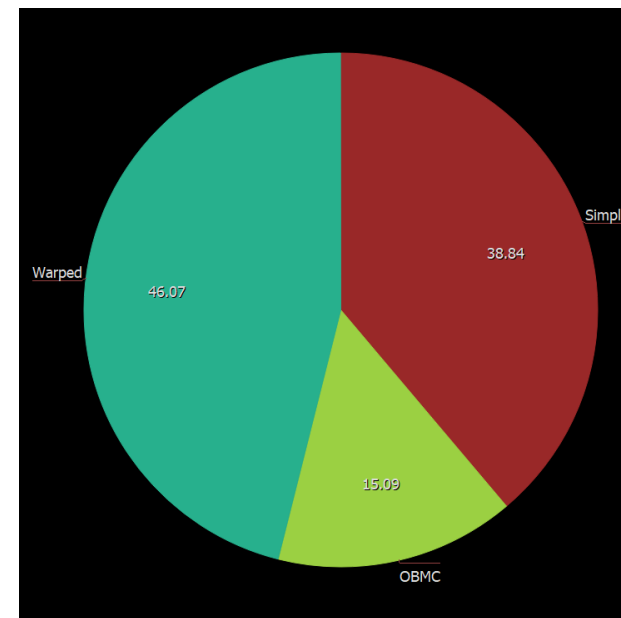
All Compound Types

# OBMC, Warp, Global Motion

- 24 OBMC
- 25 warped motion
- 26 global motion
- 27 global + warped motion
- 28 obmc+global+warped motion



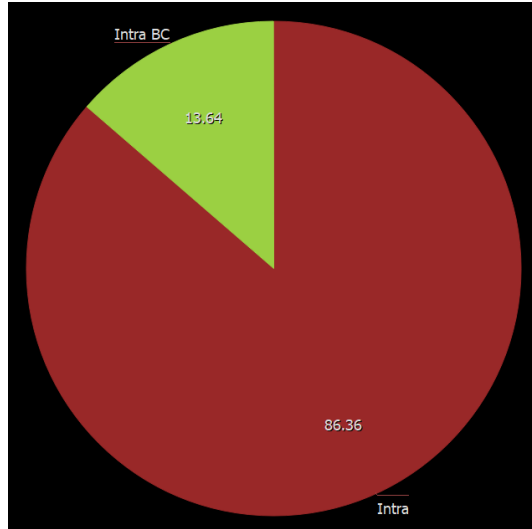
Inter Mode



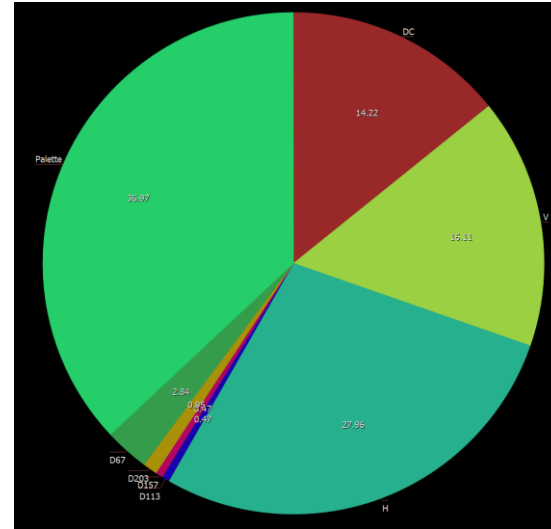
Motion Mode



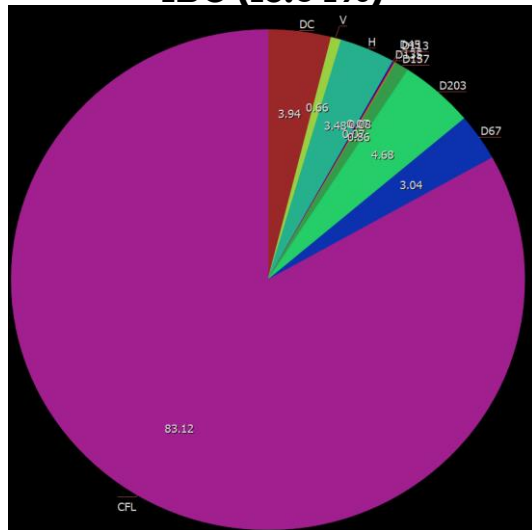
# Coding Tools for Screen Content



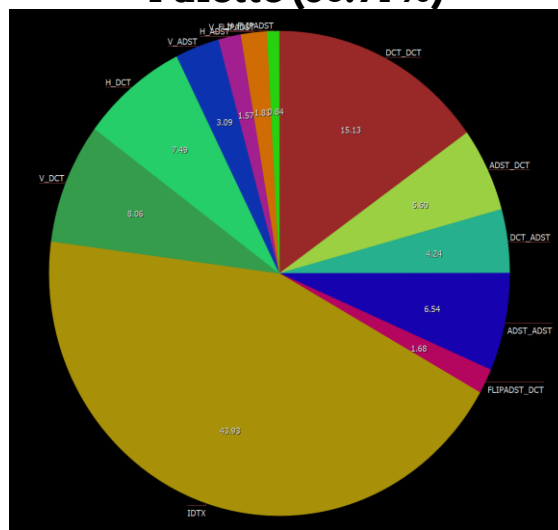
**IBC (13.64%)**



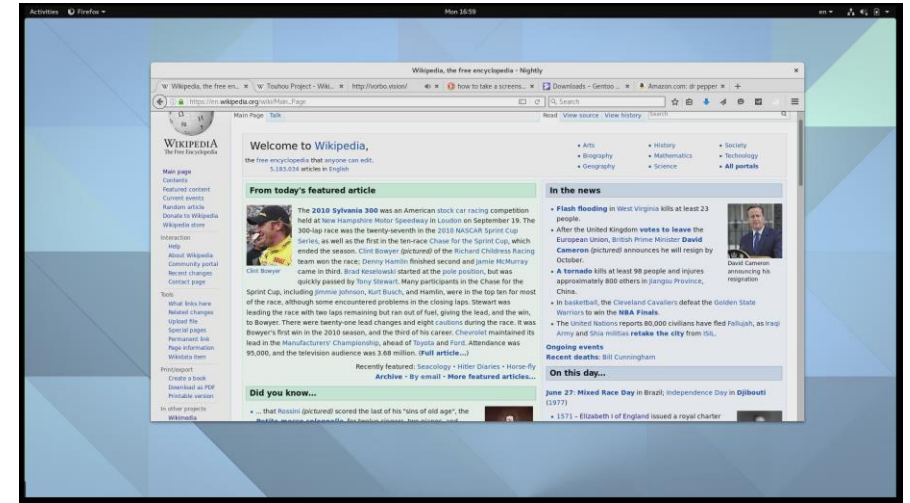
**Palette (36.97%)**



**CFL (83.12%)**



**IDTX (43.93%)**



wikipedia



Minecraft

# In-loop filtering



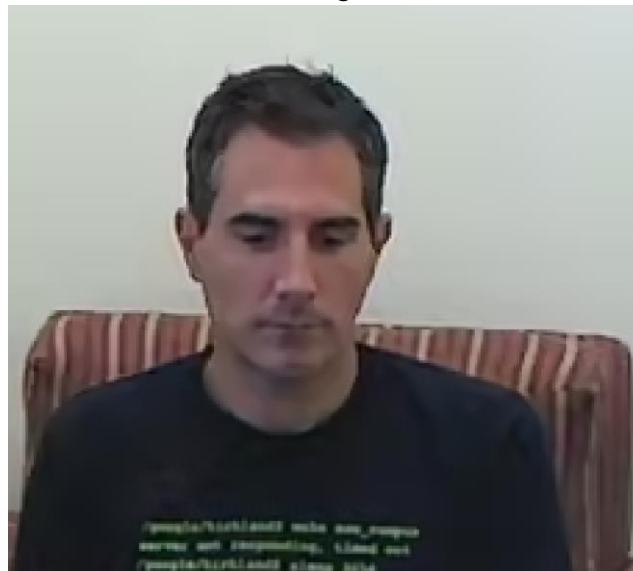
Deblocking Only



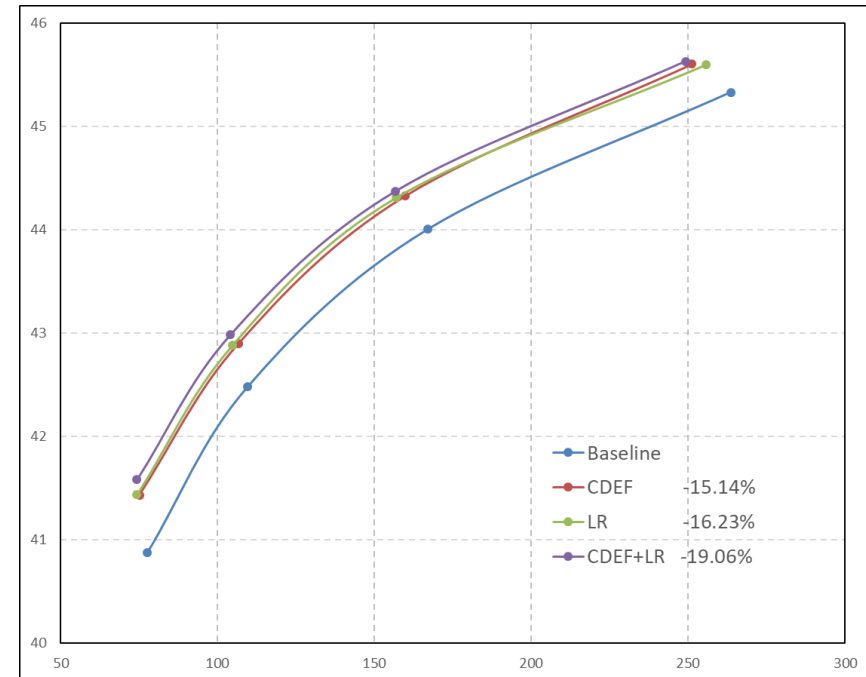
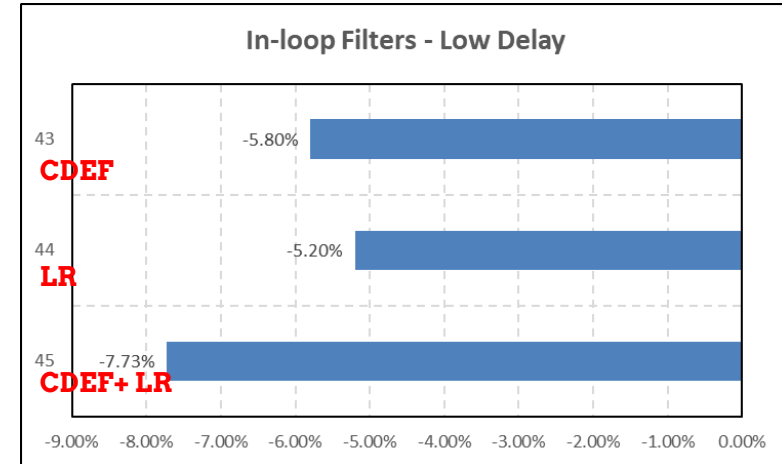
Deblocking + CDEF



Deblocking + LR



Deblocking + CDEF + LR



# Summary

- Infrastructure for “tool-on” and “tool-off” tests is implemented.
- Coding gain and effectiveness of major tools in AV1 is evaluated.
- Proposal for future AV2 development:
  - Adopt the framework for “tool-on” and “tool-off” test from the start.
  - Run the test and report the result regularly to understand the interaction between different tools.
  - Consolidate and harmonize similar coding tools at the end of development cycle.