



Viewer Intelligence™ to Deliver
The Ultimate Viewing Experience™

AV1 vs HEVC: Perceptual Evaluation of Video Encoders

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AV1 VS HEVC (AND AVC) – WHAT DO WE WANT TO KNOW?

- Does AV1 outperform HEVC and AVC on bitrate savings? By how much?
- Does the bitrate savings change with video resolution?
- Does the bitrate savings change with content?
- How does AV1 compare against HEVC in terms of computational efficiency?
- Which video quality metrics should be used to evaluate video codecs?

TEST CONDITIONS



x265



- Encoders
 - AV1
 - HEVC (x.265)
 - AVC (x.264)
- Configuration
 - One-pass encoding for target CRF
 - Very-slow preset
- Objective quality metrics
 - SSIMPLUS
 - VMAF
 - PSNR
- Subjective evaluation
 - Mean Opinion Score (MOS)



PSNR



TEST CONDITIONS

20 ten-second video clips with diverse content types

3 resolutions
540p
1080p
2160p

5 encoder types
4 quality levels

1200 test videos
In total

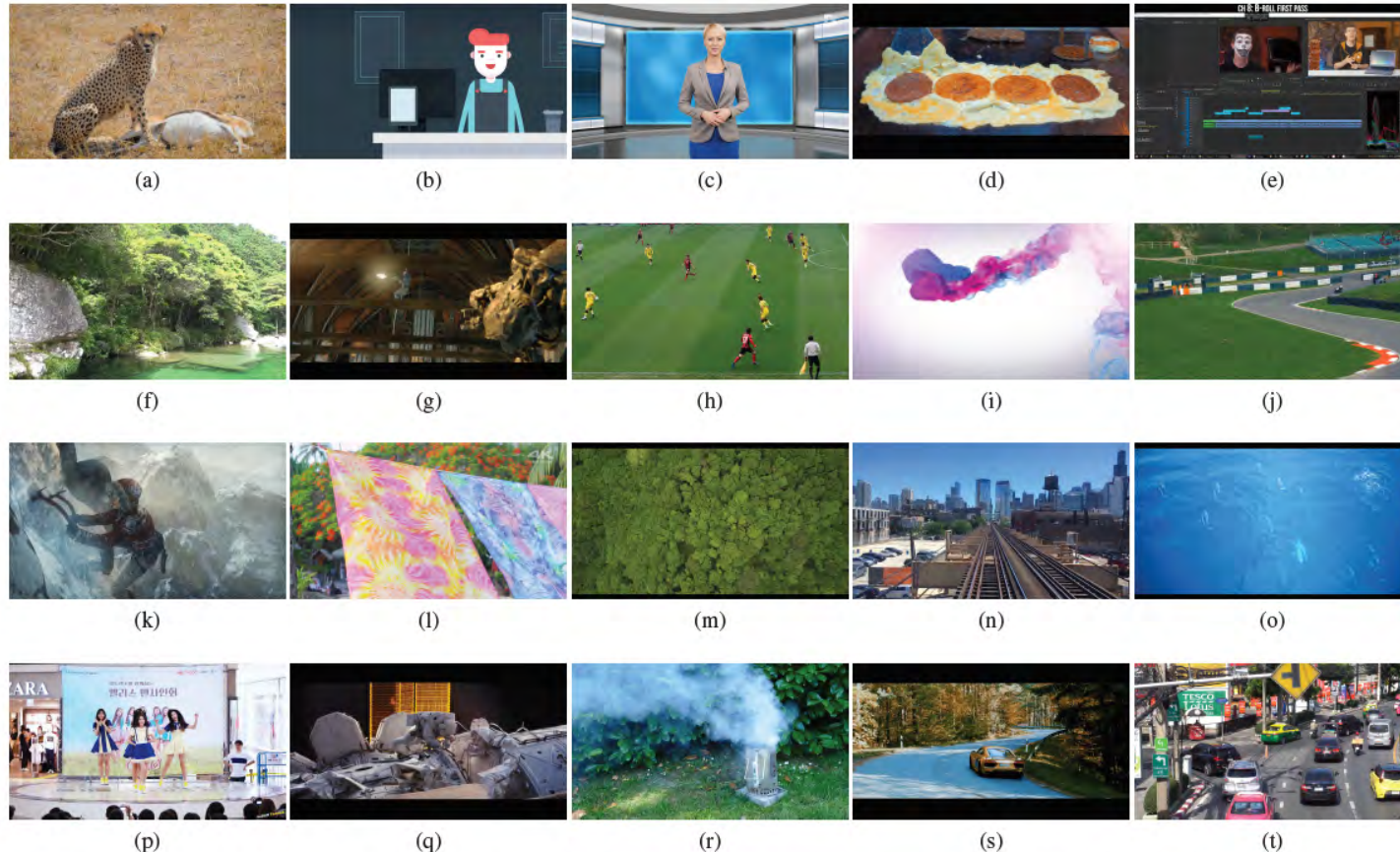


Fig. 1. Snapshots of reference video sequences. (a) Safari. (b) 2D cartoon. (c) News. (d) Teppanyaki. (e) Screen recording. (f) Botanical garden. (g) Tears of steel. (h) Soccer game. (i) Animation. (j) Motor racing. (k) Climbing. (l) Colorfulness. (m) Forest. (n) Lightrail. (o) Dolphins. (p) Dance. (q) Spaceman. (r) Barbecue. (s) Supercar. (t) Traffic.

Safari
2D Cartoons
News
Teppanyaki
Screen recording
Botanical garden
Tears of steel
Soccer game
Animation
Motor racing
Climbing
Colorfulness
Forest
Lightrail
Dolphins
Dance
Spaceman
Barbecue
Supercar
Traffic

TEST CONDITIONS

- Independent Study

at University of Waterloo & SSIMWAVE INC

- Fair Comparison (by “matching” settings as much as possible)

Very-slow pre-set, default settings

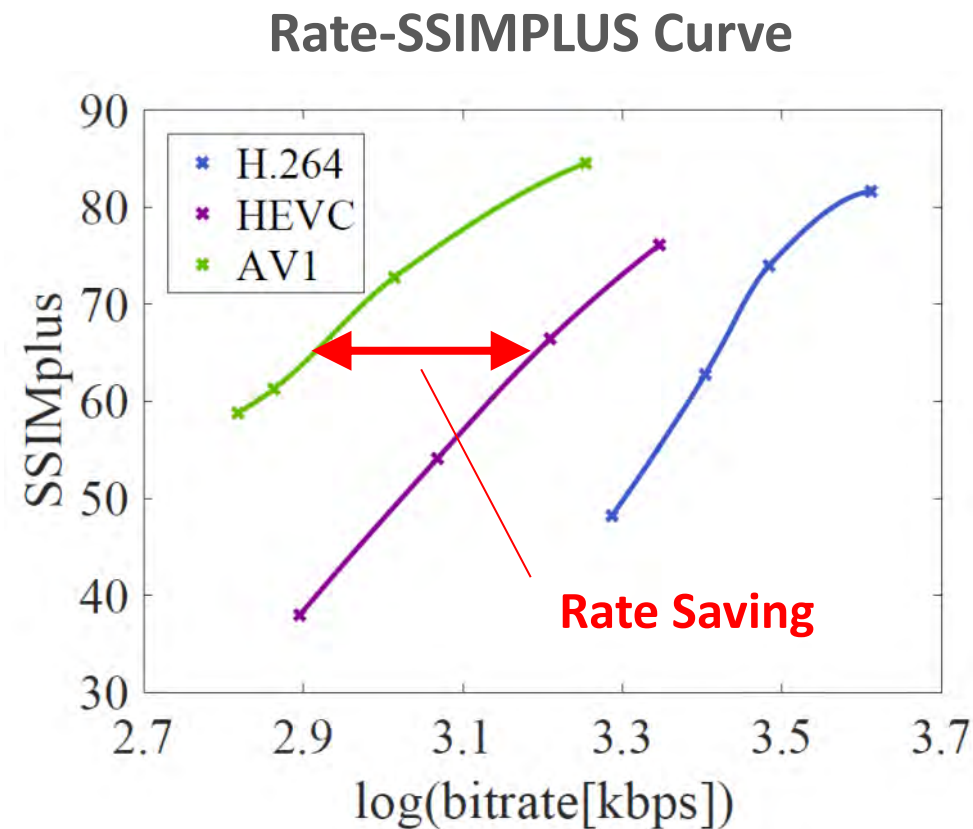
- Results NOT Conclusive

No tuning for subjective/objective metrics

No content-adaptive optimization

DOES AV1 OUTPERFORM HEVC & AVC ON BITRATE SAVINGS? BY HOW MUCH?

		AV1	HEVC	AVC
SSIMPLUS (540p)	AV1	0	-28.3%	-52.6%
	HEVC	-	0	-30.4%
	AVC	-	-	0
SSIMPLUS (1080p)	AV1	0	-28.8%	-51.2%
	HEVC	-	0	-38.5%
	AVC	-	-	0
SSIMPLUS (2160p)	AV1	0	-32.4%	-64.8%
	HEVC	-	0	-46.8%
	AVC	-	-	0



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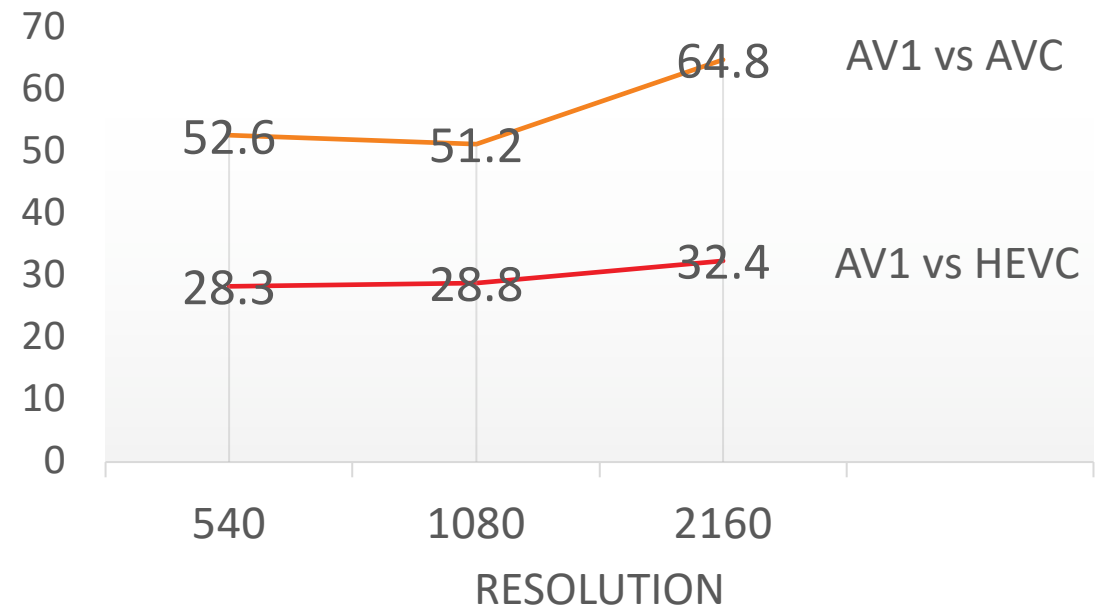
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	HEVC	-	0	-46.8%
	AVC	-	-	0

Based on SSIMPLUS quality measure
AV1 outperforms HEVC
An average rate saving of about 30%

DOES THE RATE SAVINGS CHANGE WITH RESOLUTION?

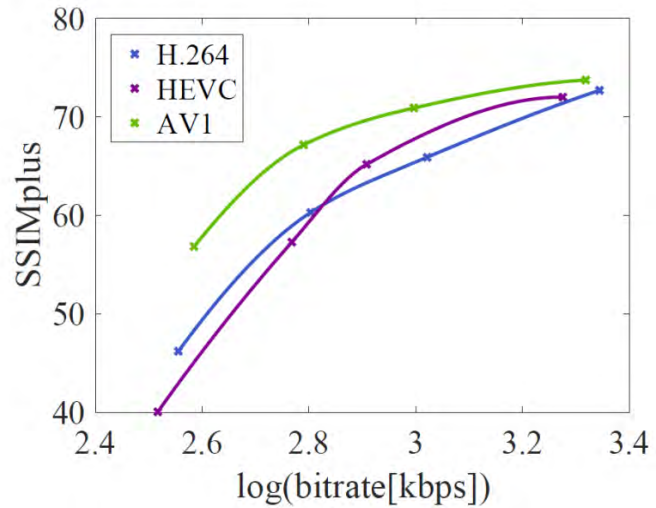
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Average Rate Saving (%) Based on SSIMPLUS

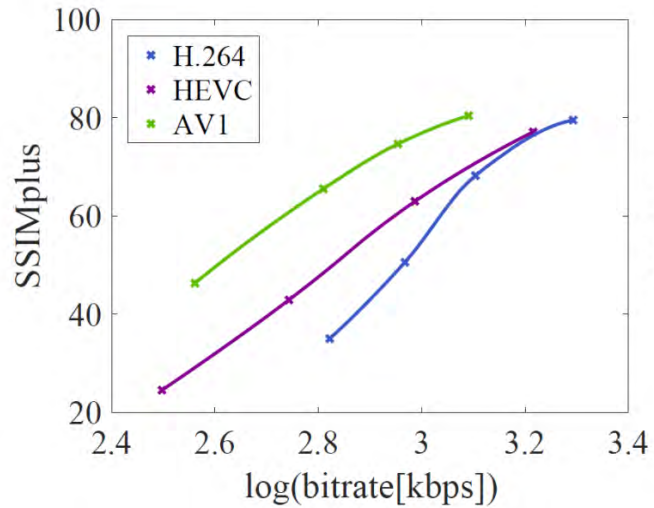
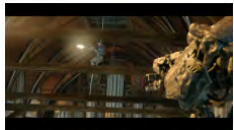


Rate saving generally increases with resolution

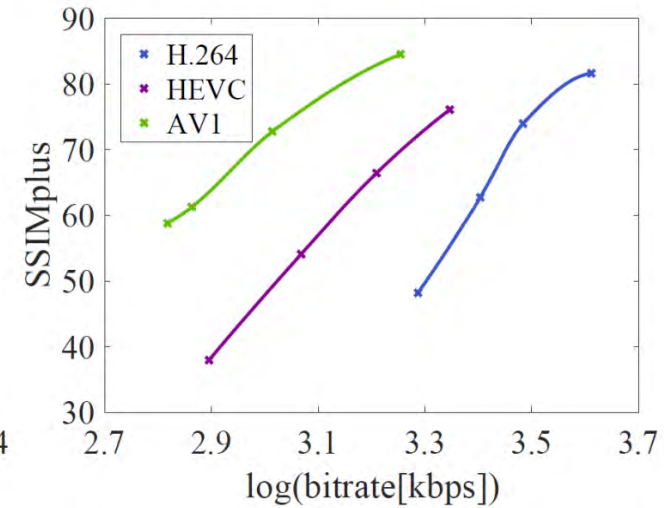
DOES THE RATE SAVINGS CHANGE WITH CONTENT?



540p



1080p

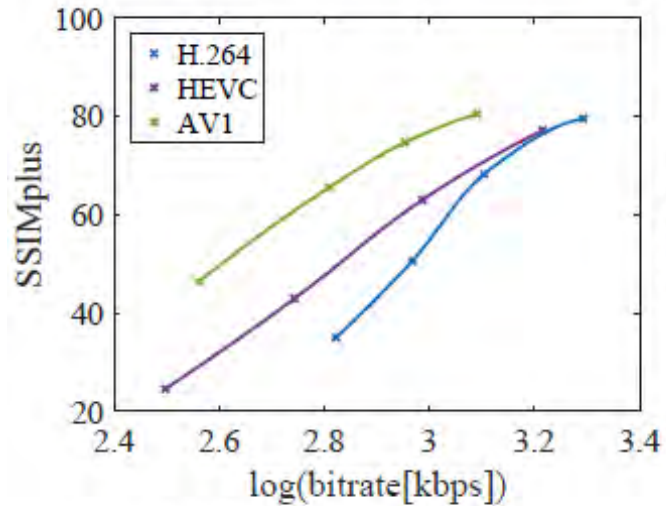


2160p

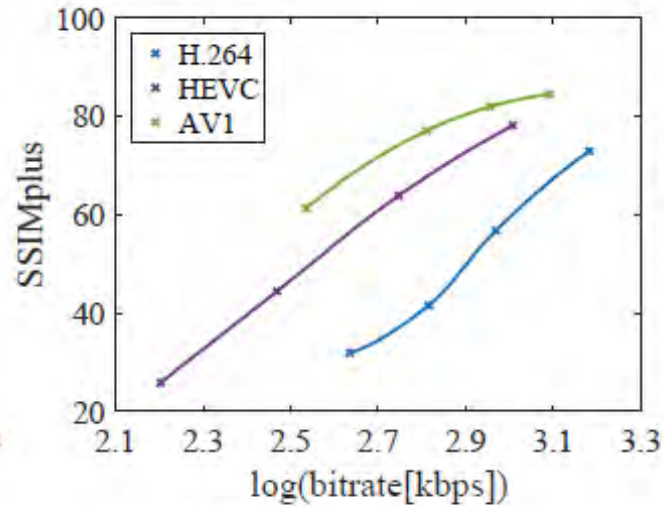
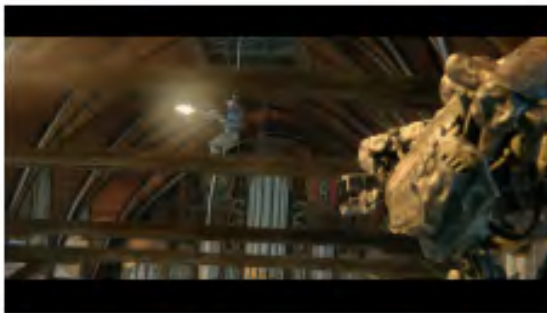


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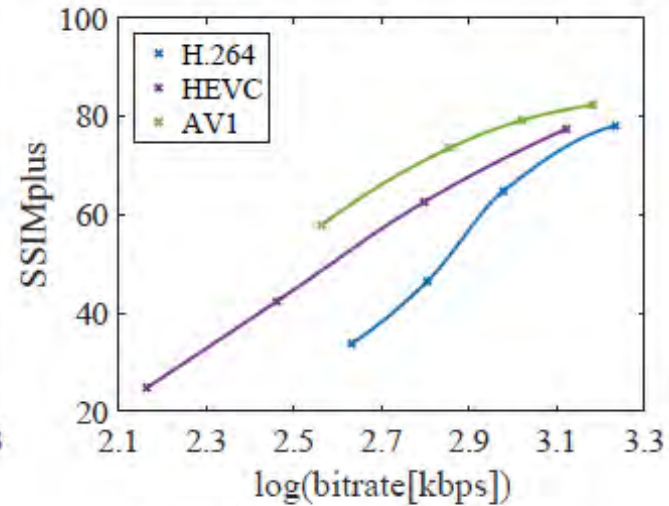
DOES THE RATE SAVINGS CHANGE WITH CONTENT?



(a) Tears of steel 1080p



(b) Soccer game 1080p



(c) Motor racing 1080p



**Rate-Quality
Performance and
Rate Savings Highly
Content Dependent**

HOW DOES AV1 COMPARE WITH HEVC & AVC ON COMPLEXITY?

Relative Computational Complexity Using AVC as Baseline

	Computation Complexity		
	4K	1080p	540p
AVC	1	1	1
HEVC	4.28	4.73	5.28
AV1	590.74	546.19	806.15

Current AV1 is extremely slow compared with HEVC or AVC

WHICH VIDEO QUALITY METRICS SHOULD BE USED TO EVALUATE VIDEO CODECS?

SSIMPLUS (2160p)		AV1	HEVC	AVC
	AV1	0	-32.4%	-64.8%
	HEVC	-	0	-46.8%
	AVC	-	-	0
PSNR (2160p)		AV1	HEVC	AVC
	AV1	0	-40.5%	-58.9%
	HEVC	-	0	-34.0%
	AVC	-	-	0
VMAF (2160p)		AV1	HEVC	AVC
	AV1	0	-34.1%	-64.8%
	HEVC	-	0	-46.5%
	AVC	-	-	0

SSIMPLUS, PSNR, VMAF all predicts large rate savings of AV1 against HEVC

SSIMPLUS and VMAF produces similar predictions

However

WHICH VIDEO QUALITY METRICS SHOULD BE USED TO EVALUATE VIDEO CODECS?

Desirable Features From A Good Video Quality Metric

- Accuracy, speed, precision (fine granularity)
- Easy-to-understand, easy-to-use
- Cross-resolution, cross-dynamic range, cross-frame rate, cross-viewer device
- Spatial alignment, temporal alignment
- Versatile, end-to-end score consistency

Great advantages of SSIMPLUS against PSNR and VMAF

SUMMARY

- AV1 produces significant rate savings against HEVC on average
- The average rate saving generally increases with resolution
- The rate saving varies dramatically across content
- Current AV1 has extremely high computational complexity
- SSIMPLUS, PSNR and VMAF all predict large rate savings of AV1 against HEVC

However, PSNR and VMAF are short of other key features