Enhancing Video Quality in Transcoding Pipelines: A Comparative VMAF Analysis

Optimizing Quality of Experience (QoE) with VisualOn's content-adaptive encoding Optimizer integration in Cires21 Streaming Platform

Abstract.

In the competitive landscape of video streaming, delivering pristine visual quality while managing bandwidth costs is paramount. This whitepaper analyzes the impact of integrating **VisualOn's content-adaptive encoding Optimizer** into the **Cires21** video transcoding pipeline.

By conducting a granular comparison of **Video Multimethod Assessment Fusion (VMAF)** scores across multiple codecs (H.264, HEVC, AV1) and hardware/software implementations, this study demonstrates how the Optimizer consistently elevates video quality. The results reveal significant VMAF improvements—particularly in lower-resolution rungs of Adaptive Bitrate (ABR) ladders—transforming the viewer experience across diverse playback environments.

Key Results

01. **The NVENC pipeline sees universal improvement, with VMAF gains of 6-15 points, pushing scores into the 90+ range.**
02. **For NETINT and Intel hardware, the Optimizer acts as a safety net for lower resolutions increasing VMAF scores by 15 to 29 points.**
03. **VisualOn brings software encoding (AVC/HEVC) closer to the theoretical maximum quality**

Introduction.

As **Cires21** continues to lead in live streaming and encoding solutions, validating the efficacy of third-party integrations is critical. VisualOn's AI-Enhanced and Award-Winning Optimizer technology claims to enhance encoding efficiency and visual fidelity through content-adaptive processing.

To verify these claims, extensive tests were conducted comparing standard encoding pipelines against those augmented with VisualOn's Optimizer. The metrics focus on VMAF, the industry-standard perceptual quality metric developed by Netflix, where a score of 100 is identical to the source, and a score difference of 6 points is generally considered a "Just Noticeable Difference" (JND) to the human eye.

Software-Based Encoding.

Software encoders offer flexibility but often struggle to balance CPU load with quality. The integration of the Optimizer showed immediate gains across the ABR ladder, specially on the higher resolutions.

H.265/HEVC (Software)

The Optimizer delivered a consistent uplift, pushing the 1080p tier further into the "excellent" quality range (>90) and significantly salvaging quality at lower resolutions.

Resolution	VMAF (Standard)	VMAF (w/Optimizer)	Improvement
1080p	90.56	92.95	+2.89
720p	84.45	88.57	+4.12
540p	76.02	82.05	+6.03 (1 JND)
432p	66.64	65.78	Neutral
360p	56.27	56.06	Neutral

H.264/AVC (Software)

H.264 remains the most compatible codec globally. The Optimizer breathed new life into this legacy standard, achieving HEVC quality levels at 1080p.

Resolution	VMAF (Standard)	VMAF (w/Optimizer)	Improvement
1080p	86.49	93.04	+6.55 (>1 JND)
720p	81.92	88.79	+6.87 (>1 JND)
540p	73.64	80.48	+6.84 (>1 JND)
432p	64.62	63.24	-1.38
360p	54.51	52.99	-1.52

Hardware Acceleration.

NVIDIA NVENC

NVIDIA's NVENC is a staple for high-density transcoding. The data indicates that VisualOn's Optimizer unlocks the full potential of NVIDIA hardware, delivering massive gains across all tested codecs.

H.265/HEVC (NVENC)

The results here are striking. The Optimizer bridges the gap between hardware speed and software quality, boosting 1080p scores by nearly 8 points.

Resolution	VMAF (Standard)	VMAF (w/Optimizer)	Improvement
1080p	87.32	95.15	+7.83
720p	79.96	91.10	+11.14
360p	50.88	66.23	+15.35

H.264/AVC (NVENC)

Resolution	VMAF (Standard)	VMAF (w/Optimizer)	Improvement
1080p	87.02	94.70	+7.68
720p	80.23	91.04	+10.81
360p	50.95	66.12	+15.17

AV1 (NVENC)

Even with the modern AV1 codec, the Optimizer provides essential gains, particularly stabilizing the lower resolutions.

Resolution	VMAF (Standard)	VMAF (w/Optimizer)	Improvement
1080p	88.22	94.63	+6.41
360p	52.02	66.76	+14.73

Hardware Acceleration.

NETINT

NETINT offers high-performance ASIC-based transcoding. The testing revealed a specific behavior pattern: while top-tier (1080p) scores remained stable, the Optimizer **revolutionized the quality of the lower bitrate ladders**, which are critical for mobile users on unstable networks.

H.265/HEVC (NETINT)

Note the massive recovery of quality in the 360p-432p range, turning unwatchable blockiness into acceptable SD video.

Resolution	VMAF (Standard)	VMAF (w/Optimizer)	Improvement
1080p	87.63	86.89	Neutral
720p	78.79	88.91	+10.12
432p	53.58	73.04	+19.46
360p	45.32	63.79	+18.47

H.264/AVC (NETINT)

Similar to HEVC, the optimization strategy clearly prioritizes lifting the "floor" of the video quality to ensure no user suffers poor experience.

Resolution	VMAF (Standard)	VMAF (w/Optimizer)	Improvement
1080p	87.21	86.83	Neutral
360p	45.09	63.67	+18.58

AV1 (NETINT)

Note: While 1080p experienced a regression, the mid-range resolutions saw consistent improvement.

Resolution	VMAF (Standard)	VMAF (w/Optimizer)	Improvement
1080p	87.79	79.11	-8.68 *
720p	78.97	82.06	+3.09
360p	48.33	56.64	+8.31

**The VisualOn R&D team is already reviewing this behaviour.*

Intel OneVPL / QuickSync

Intel's QuickSync is ubiquitous in media processing. Standard QuickSync encoding often sees a sharp "cliff" in quality as resolution drops. The VisualOn Optimizer successfully mitigates this drop-off.

H.265/HEVC (Intel)

The win is clear here, with 720p reaching near-transparent quality (~96 VMAF), 576p transitioning from poor to high quality (~92 VMAF), and low-resolution improving from unacceptably degraded to serviceable.

Resolution	VMAF (Standard)	VMAF (w/Optimizer)	Improvement
1080p	94.08	95.18	+1.10
720p	78.61	95.98	+17.37
576p	62.47	91.93	+29.46
432p	51.25	67.89	+16.64
360p	45.76	62.63	+16.88

H.264/AVC (Intel)

The same performance trend is observed:

- Minor gains at high resolution
- Large gains at mid and low resolutions
- Significant recovery of perceptual quality across constrained bitrate tiers

Resolution	VMAF (Standard)	VMAF (w/Optimizer)	Improvement
1080p	94.08	94.62	+0.54
720p	78.61	92.20	+13.59
576p	62.47	85.35	+22.88
432p	51.25	66.59	+15.34
360p	45.76	58.25	+12.49

Conclusion.

The integration of **VisualOn's Optimizer** into the **Cires21** ecosystem delivers measurable, high-impact improvements across almost all tested scenarios.

Key Findings

- **NVIDIA's NVENC Excellence:** The NVENC pipeline sees universal improvement, with VMAF gains of 6-15 points, pushing scores into the 90+ range.
- **Rescuing Low Bitrates:** For NETINT and Intel hardware, the Optimizer acts as a safety net for lower-mid resolutions, often increasing VMAF scores by 15 to 29 points. This is crucial for maintaining viewer retention on mobile networks.
- **Software Efficiency:** VisualOn brings software encoding (AVC/HEVC) closer to the theoretical maximum quality for 1080p/720p streams.

For Cires21 customers, this integration translates directly to **reduced churn, lower bandwidth requirements** for equivalent quality, and a **consistent viewing experience** regardless of the end-user's device or network conditions.

Appendix. Technical Analysis

Test Platforms

- For NVIDIA's NVENC: **NVIDIA RTX 4000 Ada Generation**.
- For NETINT's VPU: **NETINT Quadra's T2A**
- For all CPU-based tests: **AMD EPYC 74F3 24-Core** Processor
- For Intel's OneVPL/QuickSync tests: The testbeds used have **Intel Corporation Raptor Lake-P** [Iris Xe Graphics] integrated GPU and **Intel's Arc A770 16GB**.

And all tests were conducted on Cires21's Live Transcoder with VisualOn's Optimizer integration.

Test content

For these tests, we used **Netflix's Meridian test footage** — an ideal benchmark for evaluating encoder quality retention. Meridian is an open-source, mathematically hostile sequence engineered to stress-test video compression algorithms and perceptual quality metrics like VMAF. It aggregates severe spatial and temporal complexities — high-frequency film grain, volumetric fog, unpredictable motion vectors, and 4,000-nit HDR contrast extremes — making its 4K 60fps mezzanine files a pristine ground-truth reference for full-reference metric comparisons. Access to the uncompressed masters allowed our R&D team to rigorously analyze rate control behavior, expose macroblocking or chroma banding, and accurately map the convex hull for ABR ladders at the boundaries of Pareto efficiency per encoder implementation, with and without the VisualOn Optimizer enabled.

Processing performance assesment

NVIDIA's NVENC: For our 1:N ladder, we see an SM load increase of ~10% as monitored by `nvidia-smi` at full load. Throughput impact on NVENC is negligible.

Intel's OneVPL/QuickSync: For our 1:N ladder, we see an VPP (Video Post Processing) engine load increase of ~22% as monitored by `intel-gpu-top` at full load. Throughput impact on OneVPL/QuickSync is only noticeable on more complex 1:N ladders, well beyond the scope of this paper, affecting the maximum simultaneous encode sessions per GPU.

NETINT Quadra's VPUs: For our 1:N ladder, we see an AI engine load increase of ~80% as monitored by NETINT's `ni_rsrc_mon` tooling at full load.
Each of the VPUs on the Quadra T2A showed identical AI engine load, proportional to the encoding load in use, regardless of the best model load set at runtime.
Throughput impact on NETINT is noticeable on all 1:N ladders, especially as the AI engine load increases with the model(s) being loaded into the VPU.