contact: simon.bauer@ufg.ac.at

„LCEVC“
LOW COMPLEXITY ENHANCEMENT VIDEO CODEC

v 0.3

MPEG-5 LCEVC

LCEVC: **L**ow **C**omplexity **E**nhancement **V**ideo **C**odec / MPEG-5 Part 2
https://www.lcevc.org/

TL;DR. LCEVC ist ein erweiterter Layer, der in Kombination mit diversen Basiscodecs (H.264, H.265, HEVC etc.) einen verbesserten Videostream erzeugt (dual-layer encoding process).

Das Besondere am "LCEVC"-Videocodec (Low Complexity Enhancement Video Coding) ist, dass er auf einen bereits bestehenden Videocodec aufbaut, um die Videoqualität zu verbessern, ohne dabei die Komplexität des Codecs zu erhöhen. Dies wird erreicht, indem der LCEVC-Codec eine zusätzliche Enhancement Layer zum Basis-Codec hinzufügt, die dazu dient, zusätzliche Details zu codieren, ohne dass der Decoder des Basis-Codecs angepasst werden muss. Durch die zusätzliche Enhancement Layer können Feinheiten und Details im Video besser dargestellt werden, was zu einer höheren Bildqualität führt.

LCEVC ist also „codec-agnostisch“, d.h. er kann mit verschiedenen Basis-Codecs, wie H.264, HEVC oder AV1, kombiniert werden. Dies ermöglicht es, die Vorteile von LCEVC mit vielen verschiedenen Videoformaten anzuwenden. LCEVC kann relativ einfach implementiert werden, da keine Änderungen am Basis-Codec vorausgesetzt werden.

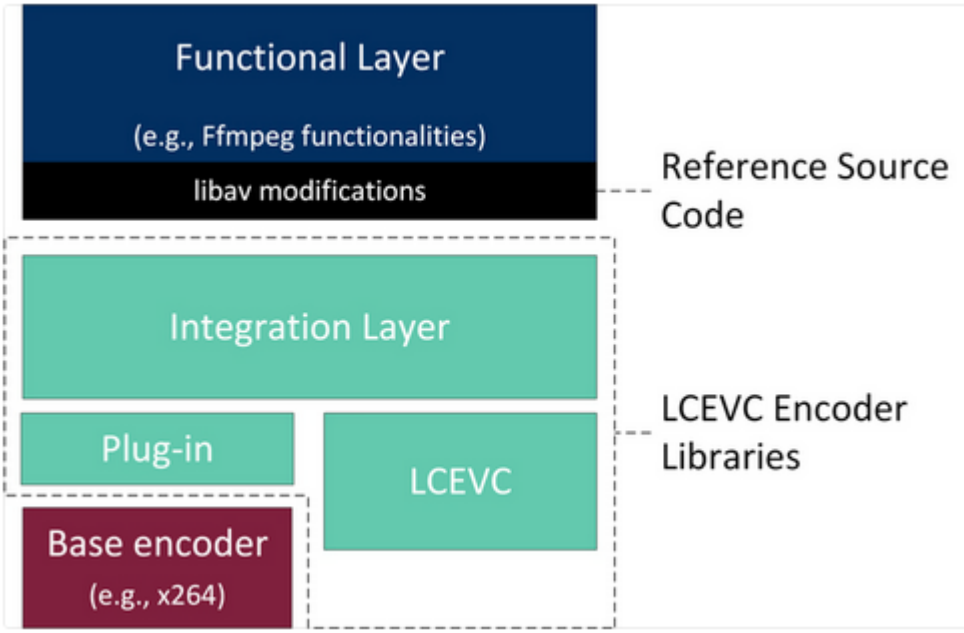


Abb. V-Nova LCEVC encoder and decoder dataflow

Der Codec ist energieeffizient und ermöglicht es, eine höhere Videoqualität bei gleicher Datenrate zu erzielen. Dies ist natürlich insbesondere für mobile Geräte interessant (Verringerung der Komplexität von Kodierung und Dekodierung).

LCEVC kann je nach Bedarf skaliert werden, indem die Qualität der „Enhancement Layer“ angepasst werden. Dies ermöglicht es wieder Bandbreite und die Verarbeitungsleistung effizienter zu nutzen, wobei LCEVC dadurch auch fehlertolerant ist, da die Enhancement Layer separat vom Basis-Codec übertragen werden. Wenn es zu Fehlern in der Enhancement Layern kommt, kann der Decoder auf den Basis-Codec zurückgreifen und ein brauchbares Bild liefern.

LCEVC unterstützt ebenso HDR und einen erweiterten Farbraum.

LCEVC kann für eine Vielzahl von Anwendungen eingesetzt werden, zB. Video-on-Demand, Live-Streaming, Videokonferenzen, Videoschnitt, Augmented Reality/Virtual Reality etc.

„MPEG-5 Part 2 LCEVC (ISO/IEC 23094-2) has officially been published by ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) reaching the final stage of its worldwide standardization process.“ (lcevc.org)

LCEVC mit H.264 als Basis (base layer) kann auf jedem H.264 kompatiblem Player abgespielt werden und hat dabei eine bessere Qualität bei niedrigen Bitraten, bietet höhere Frameraten und schnellere Wandlung bei niedriger CPU-Auslastung.

„Die technische Weiterentwicklung beim Streaming schreitet schnell voran, jedoch dauert es immer relativ lange, bis Hardwarelösungen für neue Kompressionsverfahren bereitstehen. Softwarelösungen sind dagegen flexibler, jedoch stößt die Programmierung für die klassische CPU bei der Videodatenverarbeitung schnell an Leistungsgrenzen. Dieses Problem soll LCEVC beheben, in dem die Vorteile beider Systeme miteinander verbunden werden.“

https://en.wikipedia.org/wiki/LCEVC
https://de.wikipedia.org/wiki/Low_Complexity_Enhancement_Video_Coding

Verglichen mit H.264 kann LCEVC bis zu 40% höhere Datenrateneinsparungen schaffen bei gleicher Bildqualität (HEVC 25 %, AV1 20 %)

Beispiel Basiscodecs (base video codecs):

- Advanced Video Coding (**AVC**)/H.264/MPEG-4 Part 10
  https://en.wikipedia.org/wiki/Advanced_Video_Coding
  https://de.wikipedia.org/wiki/H.264

- AOMedia Video 1 (**AV1**)
  https://en.wikipedia.org/wiki/AV1
  https://de.wikipedia.org/wiki/AOMedia_Video_1

- High Efficiency Video Coding (**HEVC**)/H.265/MPEG-H Part 2
  https://en.wikipedia.org/wiki/High_Efficiency_Video_Coding
  https://de.wikipedia.org/wiki/High_Efficiency_Video_Coding

- Essential Video Coding (**EVC**)/MPEG-5 Part 1/ISO/IEC 23094-1
  https://en.wikipedia.org/wiki/Essential_Video_Coding
  https://de.wikipedia.org/wiki/Essential_Video_Coding

- Versatile Video Coding (**VVC**)/H.266/MPEG-I Part 3/ISO/IEC 23090-3
  https://en.wikipedia.org/wiki/Versatile_Video_Coding
  https://de.wikipedia.org/wiki/Versatile_Video_Coding

Introducing MPEG-5 Part 2 LCEVC.

A codec to improve other codecs.

Geneva, ITU Workshop 2019

Why a Low Complexity Enhancement Video Coding Standard?

David Ronca

Director of Video Encoding
Facebook
(previously Netflix)

"(...)

Encoder complexity is outpacing Moore's law.

(...)

The longer-term answer to video encoding can not be to simply add more CPU capacity. This is an unsustainable model; both financially, and environmentally.

(...

Codec research must emphasize compression efficiency AND computational efficiency.
Here's a thought exercise: If the next video encoder maintained the efficiency of VVC/AV1 but reduced computational complexity by 50%, would we consider that a successful new codec?"

(from "**Encoder complexity hits the wall**", 7/10/2019)

PDF https://www.itu.int/en/ITU-T/Workshops-and-Seminars/20191008/Documents/Guido_Meardi_Presentation.pdf

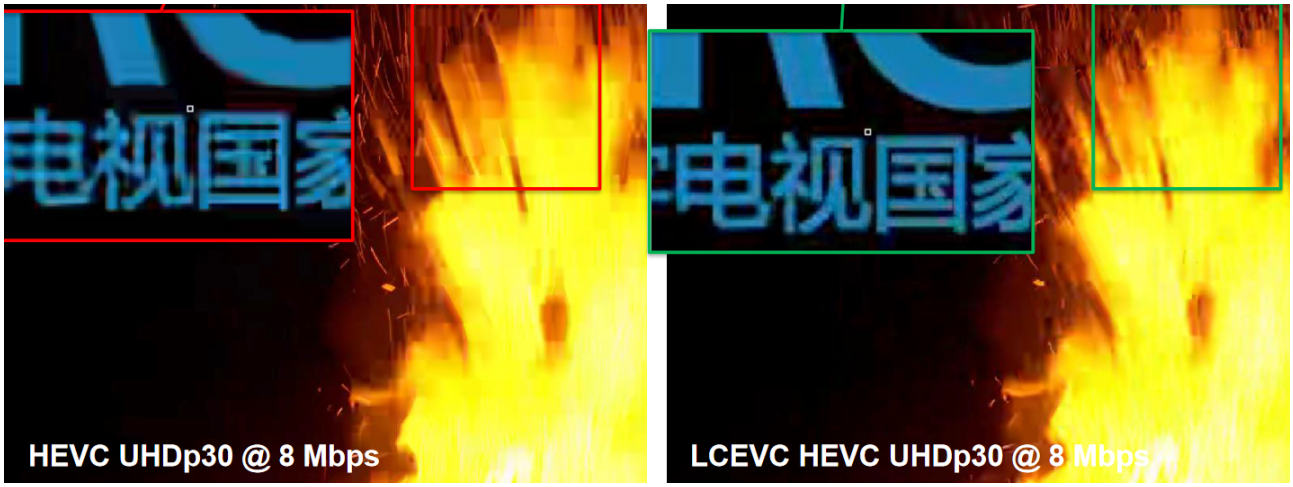


Abb. HEVC vs LCEVC HEVC jeweils bei 8 Mbps (aus Introducing MPEG-5 Part 2 LCEVC.)

Video-Beispiele

"Use the LCEVC toggle control in the player to see how MPEG-5 LCEVC enhancement increases both resolution and detail.“

Abb. LCEVC Toggle LCEVC Toggle

https://experience.v-nova.com/

Arbeitsweise

"LCEVC (Low Complexity Enhancement Video Coding) works by encoding a lower resolution version of a source image using any existing codec (the base codec) and the difference between the reconstructed lower resolution image and the source using a different compression method (the enhancement)."

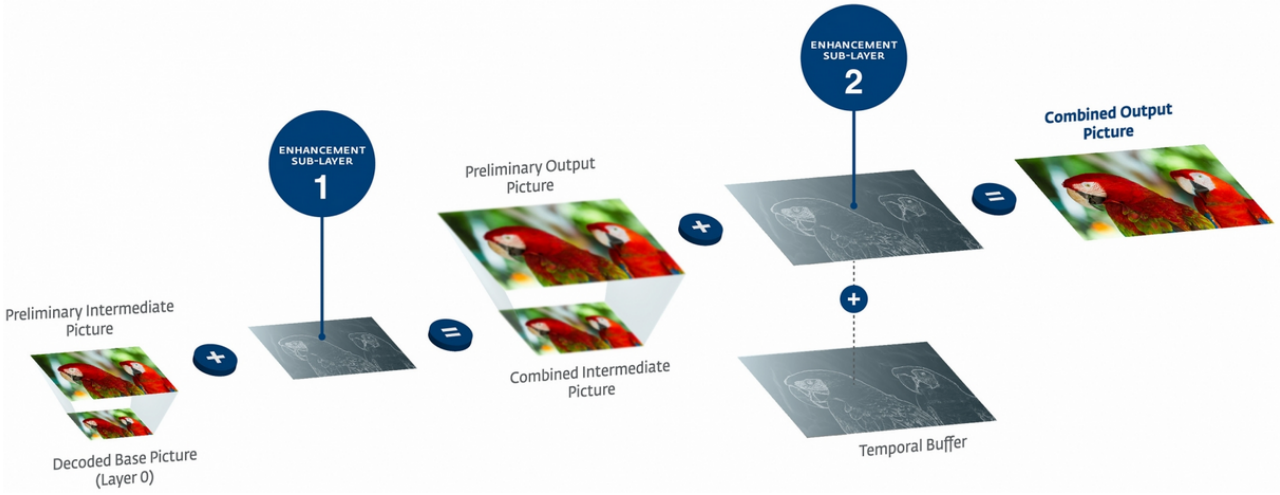


Abb. „Enhancement layer to improve compression efficiency and reduce complexity"
https://www.lcevc.org/how-lcevc-works/

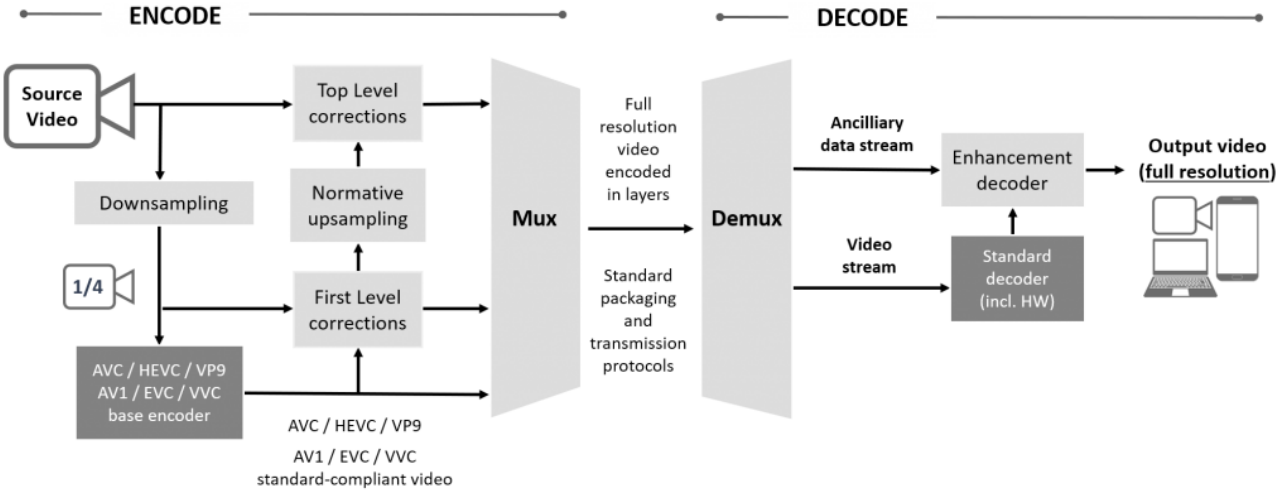


Abb. Encode/Decode

„Thanks to residual sub-layers, LCEVC uniquely combines the world of smart upsampling/super-resolution with the world of traditional coding: for the areas where smart upscaling is enough for high-fidelity reconstruction, LCEVC does not need to transmit residual data; for the areas where smart upscaling fails, LCEVC allows the encoder to efficiently send the corrections that reconstruct fidelity to the source.“

Figure 1. Source

Figure 2. Half-resolution decoded base

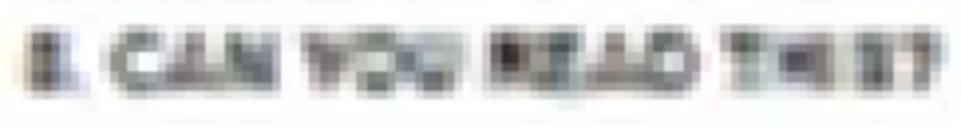


Figure 3. Base upsampled to full resolution with FFmpeg Lanczos

Abb. Figure 4. Full resolution LCEVC-enhanced output with typical large-scale distribution bitrates

V-Nova / LCEVC – A codec to improve other codecs

Introducing MPEG-5 Part 2 LCEVC. ***A codec to improve other codecs*.**

Geneva, ITU Workshop 2019
https://www.itu.int/en/ITU-T/Workshops-and-Seminars/20191008/Documents/Guido_Meardi_Presentation.pdf

V-Nova SDK

V-Nova war maßgeblich an der Entwicklung beteiligt.

„Enhance **any codec** with LCEVC. Whether you operate a social media platform, a video calling application or a live sports service, there are common key challenges that impact the success of your product or service."

Better compression	Faster encoding	Broad device support
LCEVC-AVC: 40-50%	LCEVC-AVC: 2.5x	Roll-out to all clients or phase-in deployment as non-LCEVC players can still play the base codec.
LCEVC-HEVC: 30-40%	LCEVC-HEVC: 3x	
LCEVC-AV1: 20-30%	LCEVC-AV1: >3x	
LCEVC-VVC: 15-20%	LCEVC-VVC: >3x	

Abb. Specs

„**Enhancing streams with LCEVC** allows for the **delivery of UHD** streams **at bandwidth** typically **used for HD** video. That's because LCEVC can deliver better or equivalent quality at up to 40% lower bitrates. It also enables HDR 10-bit over 8-bit codecs such as h.264 or VP9."

„Unlock AV1 and VVC streaming at scale. LCEVC is the only way to deploy latest-generation codecs such as **AV1** and **VVC** at scale by enabling you to address millions of devices that don't have dedicated hardware support for these emerging codecs. LCEVC's unique low-complexity design enables higher resolutions at sustainable battery consumption."

https://www.v-nova.com/lcevc-enhanced-video/

LCEVC Licensing Terms

V-Nova LCEVC Licensing Terms are now available for Entertainment Video Services. The terms are the following:

Free for integration

V-Nova LCEVC license is free for integration. Device or chipset manufacturers, operating systems, browsers, in-house development and encoder/player vendors can all integrate **for free.**

For Sevice Provider: V-Nova LCEVC license for usage is low-cost and based on service size (per-user licenses start from as little as $0.01 per year) and capped at $3.7 million. Designed together with customers and key industry players. V-Nova LCEVC licensing terms were designed together with customers and key industry players.

Download:
https://www.v-nova.com/try-v-nova-video-compression-technologies/

V-Nova ffmpeg/LCEVC

Es wird eine fertige ffmpeg-Version angeboten oder auch die Patches um eine eigene Implementierung durchzuführen. ***A ready-to-use ffmpeg version is offered or the patches to build your own implementation.***

„The LCEVC-enabled FFmpeg build can be easily assembled. You will have received software in the following packages:

FFmpeg	The FFmpeg binaries with support for x264 and x265
lcevc	The LCEVC libraries both encoder and decoder libraries
base codecs	Any additional base codecs requested (if applicable)

To set it all up, simply:

UnZip the FFmpeg binaries for your operating system into a local directory of your choice (or create a new one). This will be your "FFmpeg directory".

Copy the LCEVC encoder and decoder libraries with their subfolders onto the root FFmpeg directory

(Copy any additional base codecs and base codec plug-ins that you may have received from their folder onto the root FFmpeg directory (if applicable))."

https://download.v-nova.com/
https://docs.v-nova.com/v-nova/lcevc/getting-started/encoding

Hilfe-Seiten:
.\ffmpeg.exe **-help** encoder=lcevc_h264
.\ffmpeg.exe **-help** encoder=lcevc_hevc

```
C:\ffmpeg_lcevc

# ffmpeg -help encoder=lcevc_hevc
```

Suggested default command line for LCEVC x264:
.\ffmpeg.exe -i ${INPUT_PATH} -g 50 -b:v 2100k **-c:v lcevc_h264 -base_encoder x264** *-r 25 -s 1920x1080* -eil_params "preset=medium;lcevc_tune=vq" ${OUTPUT_NAME}.ts

Suggested default command line for native libx264 if you are conducting comparison tests:
.\ffmpeg.exe -i ${INPUT_PATH} -g 50 -b:v 3100k **-c:v libx264** -preset medium -bufsize 6200k -maxrate 3100k *-r 25 -s 1920x1080* ${OUTPUT_NAME}.ts

Decoding LCEVC-enhanced content
https://docs.v-nova.com/v-nova/lcevc/getting-started/decoding

.\ffplay.exe -vcodec **lcevc_h264** -i **my.ts**

Weitere Informationen:
https://docs.v-nova.com/v-nova/lcevc/reference-applications/ffmpeg

LCEVC Best Practices

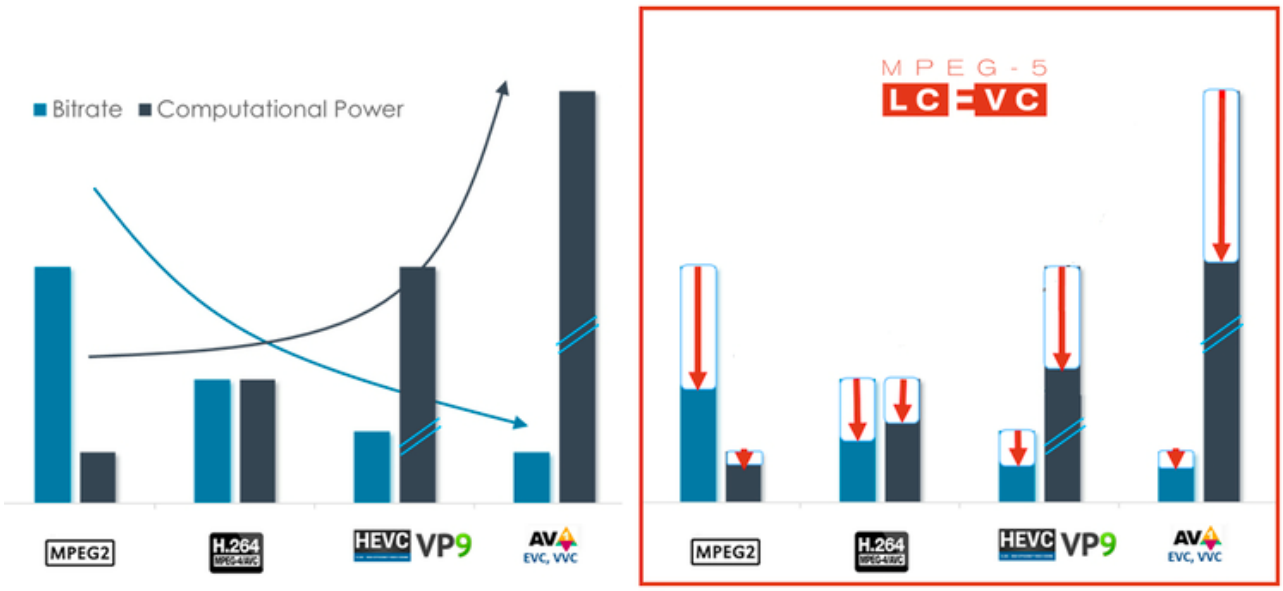


Abb. LCECV: Less Bitrate Less Processing Power
https://docs.v-nova.com/v-nova/lcevc/lcevc-best-practices

LCEVC-enhanced ABR Ladder Builder
https://docs.v-nova.com/v-nova/lcevc/lcevc-best-practices#lcevc-enhanced-h.264-avc

Download ffmpeg (lcevc Version)

„Encoding with LCEVC-enhancement is different. To get the benefits of LCEVC it's important to adjust your bitrates (typically lower) and resolutions (typically higher) compared to any existing workflows to avoid poor results. We strongly recommend reading our "LCEVC Best Practices" page for guidance if you will be encoding content as part of your evaluation.

Decoding - to play back LCEVC-enhanced content you must use an LCEVC-enabled player as standard decoders will just show the lower resolution un-enhanced video. For locally encoded content you can use our sample FFmpeg or ExoPlayer from the downloads section. For streams packaged as HLS/DASH the V-Nova demo apps are available from all major app stores or use the web player. For more information on player options go here.

Warning - All software downloaded from this site is for evaluation only and can only be used by the entity that has signed the required evaluation agreement. The software downloaded must not be shared and cannot be used for any commercial purpose. **Software can be traced to the original party that downloaded it.**“ https://download.v-nova.com/

Encoder Infos

FFmpeg binary with support of LCEVC encoding and decoding for Windows	View
FFmpeg binary with support of LCEVC encoding and decoding for Linux Ubuntu20	View
FFmpeg binary with support of LCEVC encoding and decoding for Linux Ubuntu22	View
Trial version LCEVC encoding libraries for Windows	View
Trial version LCEVC encoding libraries for Linux Ubuntu 20	View
Trial version LCEVC encoding libraries for Linux Ubuntu 22	View
Sample code to demonstrate how to use LCEVC Encoder SDK API to encode YUV file to LCEVC enhanced stream	View

Decoder Infos

Trial version LCEVC decoding libraries for Windows	View
Trial version LCEVC decoding libraries for Linux Ubuntu 20	View
Trial version LCEVC decoding libraries for Linux Ubuntu 22	View
Sample code to demonstrate how to use LCEVC Decoder SDK API and FFmpeg AVCodec to decode LCEVC enhanced stream	View

Entpacke der heruntergeladnenen Datei „ffmpeg_windows_release_x64“ (FFmpeg binary with support of LCEVC encoding and decoding for Windows)

Danach die Dateien aus dem Paket „encoder_sdk_trial_windows_release_x64“ in den Ordner des zu vor entpackten Archivs kopieren.

LCEVC Trial SDK (Encode) - 3.11

Name
FFmpeg with LCEVC support (Windows)
FFmpeg with LCEVC support (Ubuntu20)
FFmpeg with LCEVC support (Ubuntu22)
Trial LCEVC Encoder SDK libraries (Windows)
Trial LCEVC Encoder SDK libraries (Ubuntu20)
Trial LCEVC Encoder SDK libraries (Ubuntu22)
LCEVC Encoder SDK sample code

LCEVC Trial SDK (Decode) - 3.11

Name
Trial LCEVC Decoder SDK libraries (Windows)
Trial LCEVC Decoder SDK libraries (Ubuntu20)
Trial LCEVC Decoder SDK libraries (Ubuntu22)
LCEVC Decoder SDK sample code

Test per:
cd /d <Ordner-mit-ffmpeg>

.\ffmpeg.exe **-help** encoder=lcevc_h264
und
.\ffmpeg.exe **-help** encoder=lcevc_hevc

```
C:\ffmpeg_lcevc

# ffmpeg -help encoder=lcevc_hevc
```

Encoder lcevc_h264 [LCEVC Encoder / H.264 Generic Base Encoder]:

General capabilities: delay
Threading capabilities: none
Supported pixel formats: yuv420p yuv420p10le yuv420p12le yuv420p14le yuv422p yuv422p10le yuv422p12le yuv422p14le yuv444p yuv444p10le yuv444p12le yuv444p14le

lcevc_h264 AVOptions:

-base_encoder	<string>	E..V..... Specify the base encoder the IL should use
-encoding_mode	<string>	E..V..... Set encoding mode
-scaling_mode_level0	<string>	E..V..... Set scaling mode for LoQ 0
-scaling_mode_level1	<string>	E..V..... Set scaling mode for LoQ 1
-eil_params	<string>	E..V..... Supply additional EIL configuration properties as a ; separated list of key=value parameters
-epi_params	<string>	E..V..... Supply additional EPI configuration properties as a ; separated list of key=value parameters
-encoding_downsample_luma	<string>	E..V..... Set downsample_luma type (area, lanczos)
-encoding_downsample_chroma	<string>	E..V..... Set downsample_chroma type (area, lanczos)
-encoding_upsample	<string>	E..V..... Set LCEVC upsample type (cubic, linear)
-temporal_enabled	<int>	E..V..... Enable Temporal for LCEVC (from -1 to 1) (default -1)
-dc_double_upsampling_enabled	<int>	E..V..... Run with double upsampling (from -1 to 1) (default -1)
-dc_dithering_type	<string>	E..V..... Supply dithering type for LCEVC encoder (none, uniform)
-dc_dithering_strength	<int>	E..V..... set LCEVC debanding strength (from -1 to 31) (default -1)
-encoding_transform_type	<string>	E..V..... Specify the transform type to use for encoding (dd, dds)
-rc_bitrate_base_prop	<float>	E..V..... Set the average base proportion for LCEVC (from -1 to 1) (default -1)
-rc_bitrate_max_base_prop	<float>	E..V..... Set the maximum base proportion for LCEVC (from -1 to 1) (default -1)
-encoding_top_field_first	<int>	E..V..... Specify top field first encoding, or not (from -1 to 1) (default -1)
-output_filler_enabled	<int>	E..V..... Specify filler should be generated for the output (from -1 to 1) (default -1)
-pass_count	<int>	E..V..... Specify the intended number of encoding passes (from -1 to INT_MAX) (default -1)
-separate_track	<int>	E..V..... Specify that the LCEVC data should reside on a separate track (only valid for TS & MP4) (from -1 to 1) (default -1)
-lcevc_trace	<string>	E..V..... Specify filename to store LCEVC trace csv data
-external_input	<boolean>	E..V..... Indicates that input memory is passed directly to the EIL rather than copied in (default false)

Testlauf

https://docs.v-nova.com/v-nova/lcevc/reference-applications/ffmpeg#v-nova-lcevc-ffmpeg-encoder-examples-of-recommended-scripts

ffmpeg.exe -y -i greenscreen.mov **-c:v lcevc_h264** -base_encoder x264 -g 60 -b:v **450k** -eil_params "preset=medium;rc_pcrf_window_type=rolling" **output.ts**

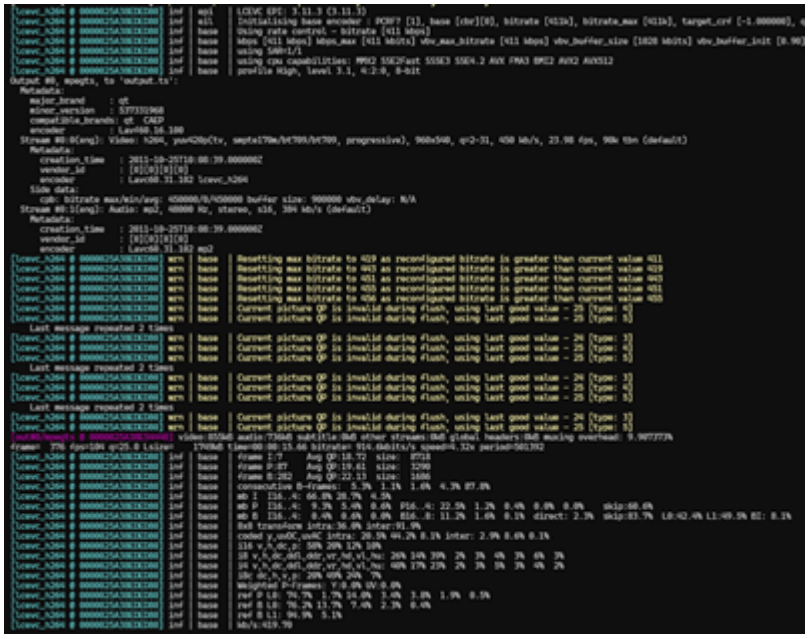


Abb. Encoding-Prozess

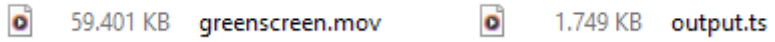
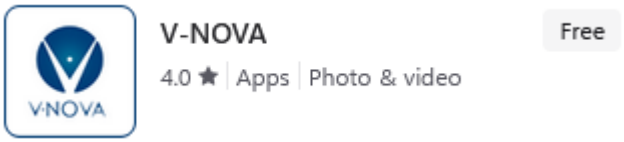
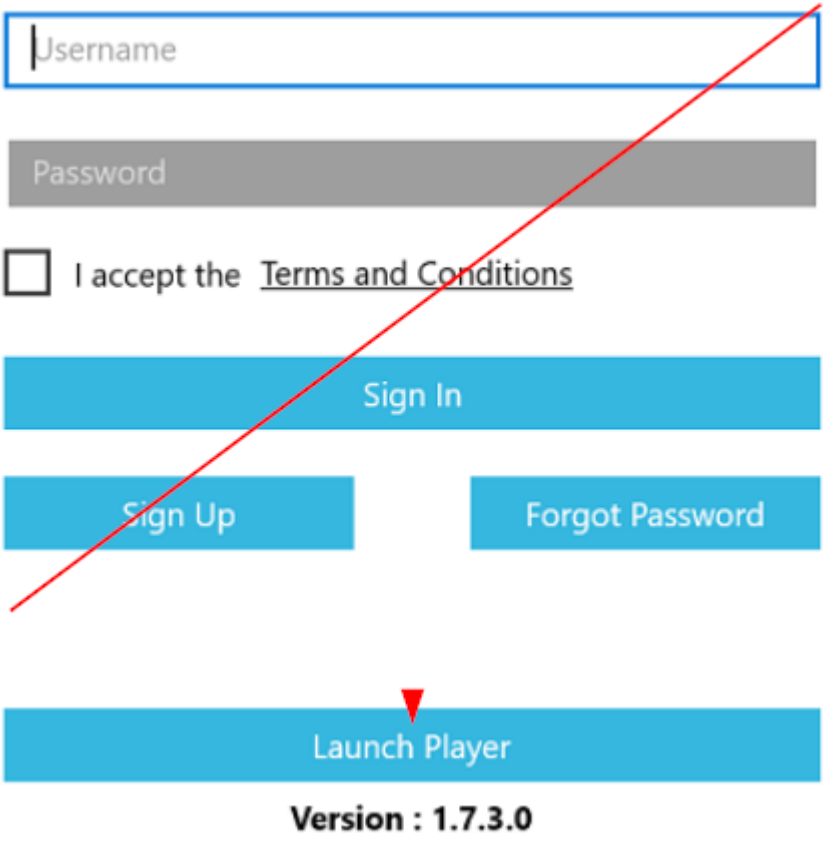


Abb. Original und LCEVC Kopie mit **450** kbps

V-Nova Player/Windows



https://apps.microsoft.com/detail/9n9c2z21xhl9



V-Nova Plattform

Auf der (Cloud-)Plattform lassen sich eigenen Videos wandeln/testen.

https://platform.v-nova.com/

Abb. Interface 'Configure Jobs'

Weitere Infos:
https://docs.v-nova.com/v-nova/v-nova-platform/encoding/platform-api

Hardware Encoder

Integration/Übersicht. Hardware-/Softwarelösungen
„Discover a range of real-world solutions that offer insights into the practical implementations of LCEVC technology, showcasing its versatility and impact on video encoding and decoding capabilities."

Allegro, AMD, Amlogic, Ateme, Harmonic, Intel, MainConcept, NETINT Technologies, NVIDIA, PresenZ, RealTek, RedpillVR, Steinwurf, THEOplayer, Videon etc.

https://www.lcevc.org/integrations/

Harmonic

„There is a lot of talk in the industry about AV1 and all of the new MPEG codecs coming out this year: VVC, EVC and LCEVC."
https://www.harmonicinc.com/insights/blog/hevc-market-perspectives-broadcast-and-streaming

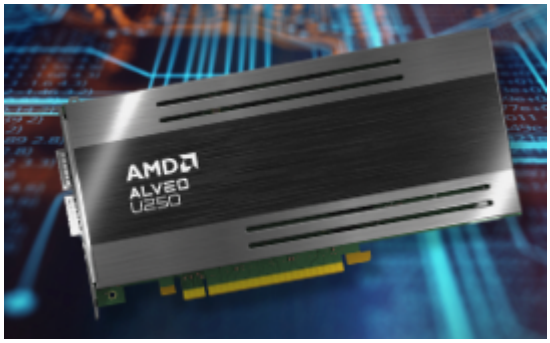
https://www.harmonicinc.com/video-streaming/video-encoders-processing/

Main Concept

„MainConcept, the leading provider of video and audio codecs, has announced the latest version of its real-time encoding application for OTT and TV broadcasting workflows, Live Encoder 3.4. It comes with two powerful additions, support for VVC/H.266 and MPEG-5 LCEVC and aims to transform the way in which broadcasters and OTT content providers distribute live video, streamline workflows, and elevate the overall viewing experience."

https://www.mainconcept.com/mainconcept-launches-live-encoder-3.4-with-vvc-and-lcevc

AMD V-NOVA LCEVC XDE / XSA



https://www.amd.com/content/dam/amd/en/documents/solutions/broadcast-and-pro-av/lcevc-xilinx-solution-brief.pdf

V-NOVA LCEVC XDE / XSA
ULTRA-DENSITY VIDEO ENCODING
READY TO CONNECT? VISIT www.xilinx.com/products/boards-and-kits/alveo.html

• V-Nova LCEVC XSA is a single board FPGA acceleration solution providing up to 4x throughput increase on existing codec deployments, whether in software or in hardware.
• V-Nova LCEVC XDE offers unparalleled encoding density as a self-contained solution for LCEVC with HEVC and other codecs running entirely on a single AMD FPGA board.
• Live 4kp60 or multiple HD streams per card
• Increase the throughput of existing servers by up to 4x
• Reduced power consumption per channel
• Reduced transcoding costs per channel
• x.264
• x.265
• VP9
• QSV
• NGCodec HEVC
• NGCodec VP9
• and more...
• Increase throughput by up to 4x: 4Kp60 or multiple HD streams per card
• Deliver higher quality at up to 50% lower bitrates
• Simple deployment for existing or new encoding operations

https://www.amd.com/content/dam/amd/en/documents/solutions/broadcast-and-pro-av/lcevc-xilinx-solution-brief.pdf

Software Player/Web/SDK

SDK/LCEVCdec

LCEVC Decoder SDK

https://github.com/v-novaltd/LCEVCdec

https://github.com/v-novaltd/LCEVCdec/blob/main/docs/getting_started.md

- Decode LCEVC compliant bitstreams
- Support for a range of formats including **YUV, NV12 (4:2:0)** and **RGBA**
- Support for a range of colour formats including **BT709 and BT2020**
- Support for HDR and 10-bit streams
- Support for ABR ladders
- CPU pixel processing stage
- Extensive API

LCEVCdecJS

V-Nova's LCEVC *decoder* ***for web***/Javascript

This project is V-Nova's implementation of the LCEVC (MPEG-5 Part 2) decoder for web-based playback.

https://github.com/v-novaltd/LCEVCdecJS

"Shaka Player is an open-source JavaScript library for adaptive media. It plays adaptive media formats (such as DASH, HLS and MSS) in a browser, without using plugins or Flash. Instead, Shaka Player uses the open web standards MediaSource Extensions and Encrypted Media Extensions. Shaka Player also supports offline storage and playback of media using IndexedDB. Content can be stored on any browser. Storage of licenses depends on browser support."

https://github.com/shaka-project/shaka-player

https://github.com/shaka-project/shaka-player/releases

Update for LCEVC Integration with new features added. (#6263) (7b717e5)
https://github.com/shaka-project/shaka-player/blob/main/CHANGELOG.md

Shaka Player LCEVC integration
https://github.com/shaka-project/shaka-player/blob/main/docs/design/lcevc-integration.md

MPEG-5 Part2 LCEVC Support

Only supported on browsers with Media Source Extensions SourceBuffer support

- MPEG-5 Part2 LCEVC decoding support (decoding provided by lcevc_dec.js, must be separately included)
- Integration documentation : docs
- More on MPEG-5 Part2 LCEVC

Demo:

https://shaka-player-demo.appspot.com/demo/#audiolang=en-US;textlang=en-US;uilang=en-US;panel=ALL_CONTENT;panelData=LCEVC;build=uncompiled

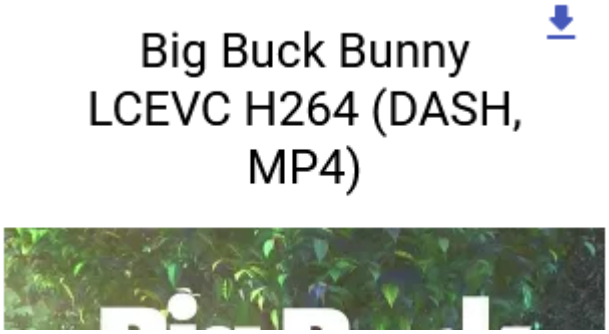


Abb. LCEVC h.264

Weitere:

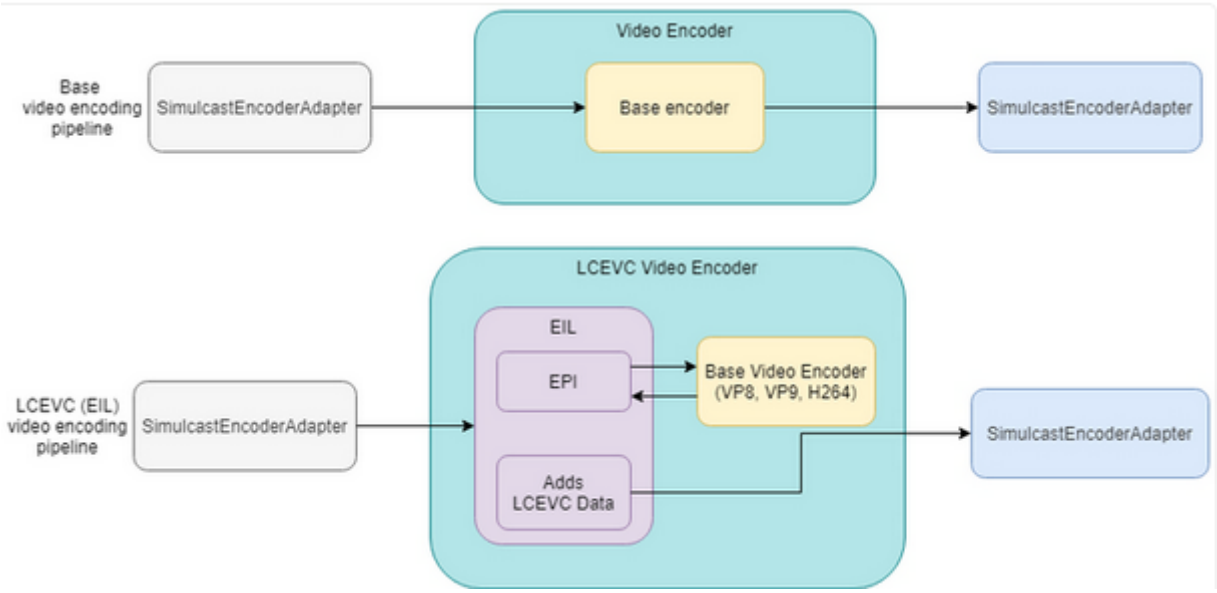
HLS.js
Embedding LCEVC-enabled demo hls.js player
https://docs.v-nova.com/v-nova/lcevc/integrations/embed

ExoPlayer with LCEVC
https://docs.v-nova.com/v-nova/lcevc/integrations/exoplayer-with-lcevc

VLCKit with LCEVC
https://docs.v-nova.com/v-nova/lcevc/integrations/vlckit-with-lcevc
video.js

AVPlayer

Die folgende Abbildung zeigt das Design der unveränderten und der mit LCEVC verbesserten Videokodierungspipeline bzgl. WebRTC.



„The V-Nova LCEVC WebRTC integration adds support for: LCEVC H264, LCEVC VP8, LCEVC VP9“

https://docs.v-nova.com/v-nova/lcevc/lcevc-in-webrtc

Test der Videoqualität

„Calculate various video quality metrics with FFmpeg.
Currently supports PSNR, SSIM, VMAF and VIF. It will output:
the per-frame metrics
metrics for each plane (Y, U, V) or components/submetrics (in the case of VIF, VMAF)
global statistics (min/max/average/standard deviation)“

https://github.com/slhck/ffmpeg-quality-metrics

ffmpeg-quality-metrics

https://github.com/slhck/ffmpeg-quality-metrics

Metric	Description	Scale	Components/Submetrics
PSNR	Peak Signal to Noise Ratio	dB	mse_avg mse_y mse_u mse_v psnr_avg psnr_y psnr_u psnr_v
SSIM	Structural Similarity	0-100 (higher is better)	ssim_y ssim_u ssim_v ssim_avg
VMAF	Video Multi-Method Assessment Fusion	0-100 (higher is better)	vmaf integer_adm2 integer_adm_scale0 integer_adm_scale1 integer_adm_scale2 integer_adm_scale3 integer_motion2 integer_motion integer_vif_scale0 integer_vif_scale1 integer_vif_scale2 integer_vif_scale3
VIF	Visual Information Fidelity	0-100 (higher is better)	scale_0 scale_1 scale_2 scale_3

ffmpeg-quality-metrics *distorted.mp4* reference.avi **--metrics psnr ssim vmaf vif**

Weitere Informationen:
Image Quality Metrics
https://www.mathworks.com/help/images/image-quality-metrics.html
SSIM https://www.mathworks.com/help/images/ref/ssim.html
PSNR https://www.mathworks.com/help/images/ref/psnr.html

Infos

Intro Video

LCEVC processing benefits are confirmed when comparing optimized implementations – Encoding

Encoding speed results
1080p, 1 Mbps

Encoding time in Seconds	x264	LCEVC	LCEVC Savings
Meridian	137	51	62.8%
Football	158	65	*58.9%*

Frames per second	x264	LCEVC	
Meridian	13	35	*2.7x*
Football	11	28	2.5x

- LCEVC improves x264 encoding speed by **2.5-2.7X**
- Even higher gains for more complex codecs (up to **4X** for AV1 and VVC)

https://www.youtube.com/watch?v=BklD_Tp_MJA

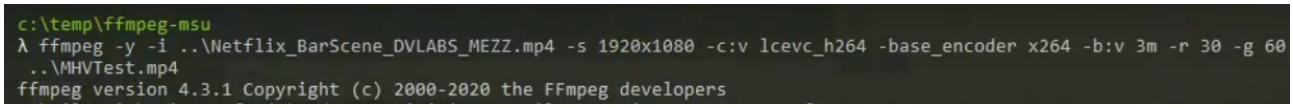


Abb. Encoding

Abb. Windows Codec

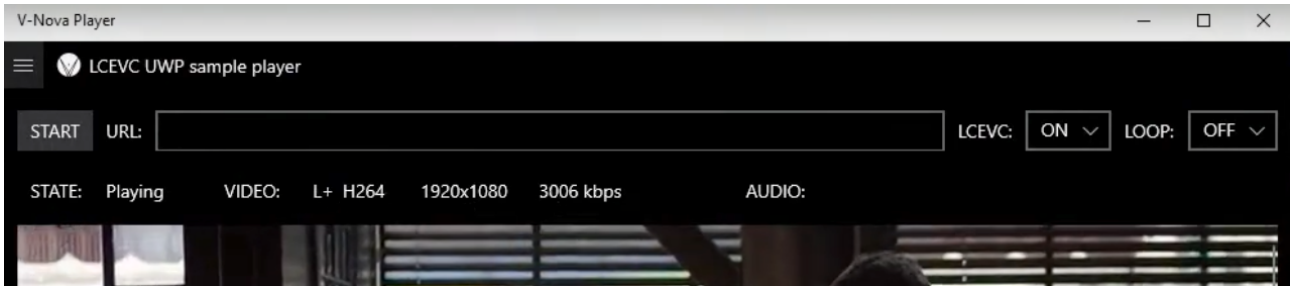


Abb. V-Nova Player

Weitere MVH Videos: https://www.youtube.com/@MileHighVideo/videos

MPEG-5 part 2: Low Complexity Enhancement Video Coding (LCEVC): Overview and performance evaluation

„Ferrara, Simone & Meardi, Guido & Ciccarelli, Lorenzo & Maurer, Florian & Battista, Stefano & Byagowi, Ahmad & Cobianchi, Guendalina & Poularakis, Stergios. (2020).

MPEG-5 part 2: Low Complexity Enhancement Video Coding (LCEVC): Overview and performance evaluation.

44. 10.1117/12.2569246.

Low Complexity Enhancement Video Coding (LCEVC) is a new MPEG video codec, currently undergoing standardization as MPEG-5 Part 2. **Rather than being another video codec, LCEVC enhances any other codec (e.g. AVC, VP9, HEVC, AV1, EVC or VVC) to produce a reduced computational load and a compression efficiency higher than what is achievable by the enhanced codec used alone for a given resolution, especially at video delivery relevant bitrates. The core idea is to use a conventional video codec as a base codec at a lower resolution and reconstruct a full resolution video by combining the decoded low-resolution video with up to two enhancement sub-layers of residuals encoded with specialized low-complexity coding tools.“**

https://www.researchgate.net/publication/343805282_MPEG-5_part_2_Low_Complexity_Enhancement_Video_Coding_LCEVC_Overview_and_performance_evaluation

Verification Test Report on the Compression Performance of Low Complexity Enhancement Video Coding (2020-05-13)

„This document provides the report on LCEVC compression performance verification: Verification Testing of LCEVC for standard dynamic range (SDR) content. The first set of tests compared full-resolution LCEVC-enhanced encoded sequences with full-resolution single-layer anchors. The average bit rate savings for LCEVC when enhancing AVC were determined to be approximately 46% for UHD and 28% for HD. The average bit rate savings for LCEVC when enhancing HEVC were determined to be approximately 31% for UHD and 24% for HD. Numerical analysis of the average benefit of LCEVC and its statistical significance compared to the corresponding full resolution EVC or VVC codec was more difficult to interpret, due to several test points having overlapping confidence intervals. However, the test results tend to indicate an overall benefit when using LCEVC with these two codecs.

The second set of tests aimed to confirm that LCEVC provided a more efficient means of resolution enhancement of half resolution anchors than unguided up-sampling. For these tests, the test sequences were coded using AVC, HEVC, EVC, or VVC at half resolution in both, horizontal and vertical direction. For anchor generation, the half resolution encoded sequences were upsampled with Lanczos filters to full resolution for visual assessment. The same half resolution encoded sequences were also used as base layers for LCEVC and hence not all curves may overlap as much as would be ideal when calculating a BD-rate. Comparing LCEVC full-resolution encoded sequences with the up-sampled half-resolution anchors, the average bit-rate savings when using LCEVC with AVC, HEVC, EVC, and VVC were calculated to be approximately 28%, 34%, 38%, and 33% respectively for UHD, and 27%, 26%, 21%, and 21% respectively for HD.“

https://www.lcevc.org/wp-content/uploads/MPEG-Verification-Test-Report-on-the-Compression-Performance-of-LCEVC-Meeting-MPEG-134-May-2021.pdf

Playback Performance/Mobile Devices

LCEVC enhanced AV1 decoding on mobile devices, V-Nova2021

https://www.lcevc.org/wp-content/uploads/AV1-with-LCEVC-pub-1.pdf

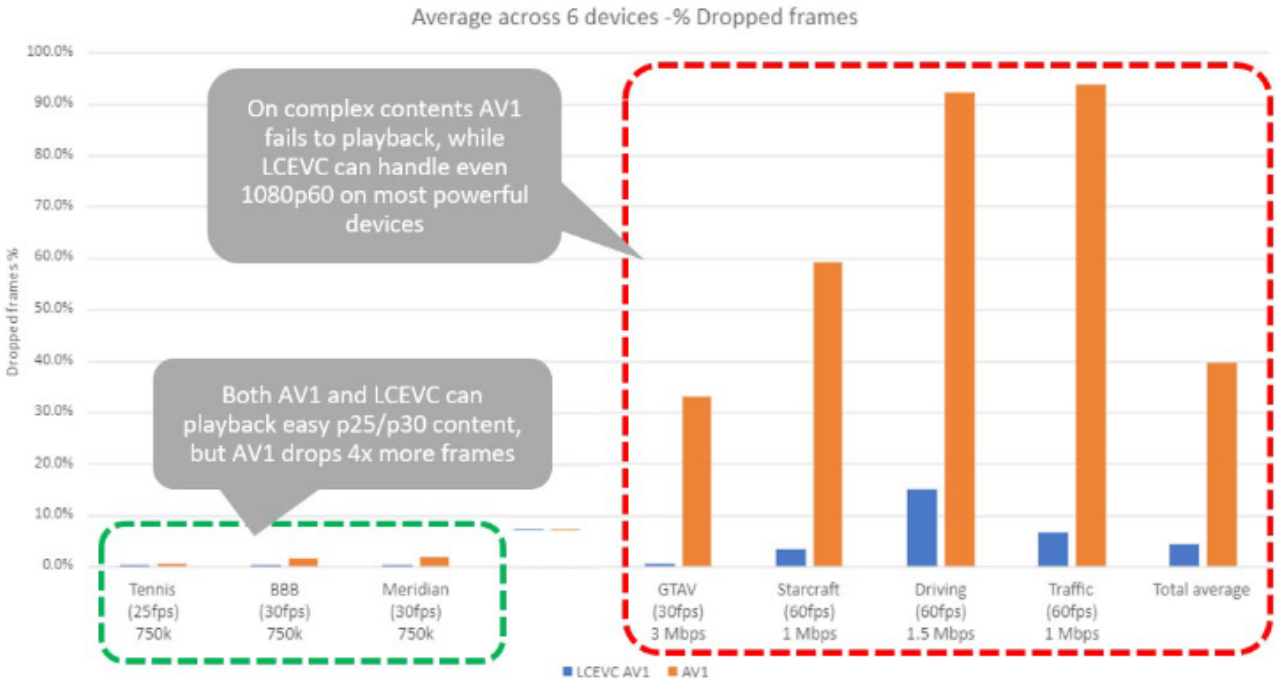


Abb. % „dropped frames“

Performance evaluation of mpeg-5 part 2 (lcevc): impact of packet loss

"This paper presents an evaluation of the latest MPEG-5 Part 2 Low Complexity Enhancement Video Coding (LCEVC) for video streaming applications using best effort protocols. LCEVC is a new video standard by MPEG, which enhances any base codec through an additional low bitrate stream, improving both video compression efficiency and and transmission. However, there is an interplay between packetization, packet loss visibility, choice of codec and video quality, which implies that prior studies with other codecs may be not as relevant. The contributions of this paper is, therefore in twofold: It evaluates the compression performance of LCEVC and then the impact of packet loss on its video quality when compared to H.264 and HEVC.The results from this evaluation suggest that, regarding compression, LCEVC outperformed its base codecs, overall in terms average encoding bitrate savings when using the constant rate factor (CRF) rate control. For example at a CRF of 19, the average encoding bitrate was reduced by 18.7% and 15.8% when compared with the base H.264 and HEVC codecs respectively. Furthermore, LCEVC produced better visual quality across the packet loss range compared to its base codecs and the quality only started to decrease once packet loss exceeded 0.8-1%, and decreases at a slower pace compared to its equivalent base codecs. This suggests that the LCEVC enhancement layer also provides error concealment. The results presented in this paper will be of interest to those considering the LCEVC standard and expected video quality in error-prone environments“

https://link.springer.com/article/10.1007/s11042-023-17931-0
https://link.springer.com/content/pdf/10.1007/s11042-023-17931-0.pdf

HDR video coding with MPEG-5 LCEVC

„Jiménez-Moreno, Amaya & Ciccarelli, Lorenzo & Clucas, Rick & Ferrara, Simone. (2022).

HDR video coding with MPEG-5 LCEVC.
25-31. 10.1145/3510450.3517307.

High Dynamic Range (HDR) video content is continuing to gain market relevance for both streaming and brodacasting services, providing video with improved contrast and colour depth. However, the predominance of 8-bit based codecs and the wide availability of Standard Dynamic Range (SDR) devices still poses challenges regarding effective deployment of HDR content.

MPEG-5 LCEVC is a new video coding standard that works in combination with a separate video standard (e.g., AVC, HEVC, VVC, AV1) to enhance the quality of a video. The enhanced quality is provided by adding details coded through an enhancement layer to a lower resolution version of the same video coded through a base layer. These enhancement layers can be used to add an HDR enhancement layer to any underlying codec, even to 8-bit based codecs, which helps to achieve a more efficient encoding and solves backward-compatibility issues.

In this paper, we describe **how LCEVC enables the encoding of HDR video**, explaining some of the main tools to provide higher efficiency for this content. Moreover, we provide a series of test results and comparisons of encoding HDR using LCEVC to enhance different video codecs.“

https://www.researchgate.net/publication/359318907_HDR_video_coding_with_MPEG-5_LCEVC

https://www.lcevc.org/wp-content/uploads/MHV22_paper_HDR_video_coding_with_MPEG5_LCEVC_camera_ready.pdf

White paper on Low Complexity Enhancement Video Coding (LCEVC) / ISO/IEC JTC 1/SC 29/AG 3

https://www.lcevc.org/wp-content/uploads/Whitepaper-on-Low-Complexity-Enhancement-Video-Coding-LCEVC-MPEG-meeting-137-January-2022.pdf

Verification Test of the Low Complexity Enhancement Video Coding (LCEVC) Standard

IEEE https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=10019298

Overview of the Low Complexity Enhancement Video Coding (LCEVC) Standard

https://ieeexplore.ieee.org/document/9795094

Weitere

Comprehensive Guide to LCEVC (MPEG-5 Part 2) – Low Complexity Enhancement Video Coding
https://ottverse.com/lcevc-mpeg5-part2-low-complexity-enhancement-video-coding-guide/

LCEVC vs. AVC – Incredible 28% Gain at 3x Speed
https://ottverse.com/lcevc-vs-avc-using-ffmpeg/

Links Ressourcen

lcevc.org
https://www.lcevc.org/lcevc-resources/

v-nova.com
https://www.v-nova.com/v-nova-video-compression-technology-resources